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Land Company

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David R. Sporer
Director of Engineering & Construction

January 11, 2008

VIA EMAIL

Ms. Diana Mally
U.S. EPA, Remedial Response Branch #2
77 West Jackson Blvd – Mail Code: SR-6J
Chicago, Illinois 60603

Re: Administrative Order on Consent for Removal Action, Docket No. VW-05-C-810
Removal Action Work Plan for Village Harbor Southwest Corner

Dear Ms. Diana Mally:

Attached for your review and approval is the Removal Action Work Plan for Village Harbor Southwest Corner, including Figures. The Appendices to this Plan are contained in two additional emails, due to their size. A hard copy will also be sent to you and to Bob Wagner at the DEQ.

If you have any questions, please give me a call.

Sincerely,

David R Sporer

David R. Sporer
Project Coordinator

cc: Ralph Dollhoph, EPA
Rodger Field, EPA Regional Counsel
Rachel Schwarz, Odawa
Robert Wagner, MDEQ
Scott Kendzierski, Health Agency
Ellen Richard, Barr Engineering
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Phil Grashoff, Esq., Boyne

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DRAFT FOR FEDERAL AND STATE REVIEW

CMS Land Company

Removal Action Work Plan
Village Harbor Southwest Corner

Little Traverse Bay CKD Release Site
Emmet County, Michigan

January 2008

ARCADIS

DRAFT FOR FEDERAL AND STATE REVIEW

Removal Action Work Plan

Village Harbor Southwest Corner

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CMS Land Company

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January 7, 2008

Figures

Tables

Appendices

1. Introduction

This Removal Action Work Plan (Work Plan) has been prepared on behalf of CMS Land Company and CMS Capital, LLC to describe the selected removal action activities to be completed in the southwest corner area of Village Harbor as per the Administrative Order on Consent for Removal Action (AOC or Order) for the Little Traverse Bay (LTB) Cement Kiln Dust (CKD) Release Site (Site) (Docket No. VW-05-C-810, February 22, 2005). CMS Land Company and CMS Capital, LLC (referred to collectively as CMS) have agreed to carry out the activities required by the Order.

This Work Plan describes a sediment removal action and subsequent installation of a cover over remaining residuals in the southwest corner area of Village Harbor, with the objective of mitigating elevated pH observed in the surface water in this area. The removal action will result in excavation and off-site disposal of approximately 580 to 730 cubic yards (cy) of sediments and lake bed materials.

1.1 Site Location and Description

1.1.1 Site Location

“Village Harbor” as used in this Removal Action Work Plan refers to the water body located immediately west of Resort Township’s East Park and immediately east of the Bay Harbor commercial district. A site location map for Village Harbor is shown on Figure 1-1, and a site plan for Village Harbor is shown on Figure 1-2.

Village Harbor is a constructed surface water feature connected to Little Traverse Bay of Lake Michigan, and is surrounded on the south, west and north by residential, commercial, and undeveloped properties associated with the Bay Harbor development. Village Harbor contains a number of docks associated with private residences located north, west, and south of the harbor. Village Harbor is a portion of the Little Traverse Bay CKD Release Site, which is located along 5 miles of shoreline on Little Traverse Bay of Lake Michigan. The Little Traverse Bay CKD Release Site is approximately 5 miles west of the City of Petoskey, and located in Resort Township, Emmet County, Michigan (Township 34N, Range 6W, Sections 2 through 10).

1.1.2 Site Description

Village Harbor is approximately 1,200 feet long and 150-200 feet wide, as shown on Figure 1-2. It is elongated in the east-west direction, with a western arm that becomes elongated in the north-south direction. Maximum water depths on transects spanning the Harbor ranged from 12 to over 20 feet. The deepest part of the Harbor (the "sump area") is in the central (east-west oriented) portion, where depths reach over 20 feet. Vehicular access to Village Harbor is via a utility road which leads to the southwest corner of the harbor. Access from Lake Michigan is through an approximately 150 foot wide boat channel on the far eastern side of the Harbor. The boat channel portion of Village Harbor was cut through rock as part of Bay Harbor development activities to allow boat access to Village Harbor.

The southwest corner area of Village Harbor is characterized by a limited area of elevated-pH (greater than 9 standard units [s.u.]) in near-bottom surface water. The source of the elevated pH in near-bottom surface waters in the southwest corner area is likely to be lake bottom materials that impact surface water and/or groundwater venting in this area. Reactive, cement kiln dust (CKD)-like material has been observed in soil borings performed in the southwest corner area. The uppermost sediment in the southwest corner appears to be a layer of secondary precipitate which overlies a layer of cobble-size limestone material. This material is believed to originate from precipitation reactions caused by neutralization of alkaline water carrying dissolved solids upon mixing with surface water from Village Harbor. Section 1.3 presents a summary of previous investigations performed to characterize sediment and surface water conditions in the southwest corner.

1.2 Site History

Village Harbor is located on the site of an historic limestone quarry and cement manufacturing operation. Historical aerial photographs from the years 1938, 1952, 1973, 1974, and 1993 were obtained for the Village Harbor area from Environmental Research, Inc., by Barr Engineering (Barr) for the *Summary of Current Conditions/Work Plan for Village Harbor* (Barr, August 9, 2006). These aerial photographs, reproduced in this report in Appendix A, document past quarrying activities and development of Village Harbor.

By 1938, the future location of Village Harbor was quarried and benched in a manner typical of a limestone quarry. In the 1952 photograph, the quarry sump is visible, as it is in the 1974, 1981, 1992 and 1993 photographs. This area coincides with the current Sump Area of Village Harbor. The 1974 and 1981 photographs show the current Sump Area containing a cloudy material. The series of photographs indicate that the Sump Area was periodically dredged to remove fines (cloudy material) that had drained into it over time. Based on recent sediment probing performed by Barr and BBL, Inc.

(formerly BBL, now ARCADIS BBL) the fines deposited in the former quarry sump were likely CKD or cement fines. Some of the historical aerial photographs show evidence of this material draining into the former sump from the cement plant, which was located approximately 500 feet to the west.

1.3 Summary of Previous Investigations

Previous investigations of site conditions are described in the following documents:

- *Summary of Current Conditions/Work Plan for Village Harbor* (Barr, August 9, 2006).
- *Village Harbor Proposed Removal Action Alternatives Report, Southwest Corner* (CMS, November 7, 2006).
- *Supplemental Sediment Borings – Southwest Corner Area, Remedial Investigation, Village Harbor* (BBL, an ARCADIS Company, December 2006).

Various remedial alternatives were also described and evaluated in the *Village Harbor Proposed Removal Action Alternatives Report, Southwest Corner* (CMS, November 7, 2006). Information contained in these reports is summarized in the following subsections. The *Supplemental Sediment Borings* report (BBL, December 2006) is included as Appendix B.

1.3.1 Bathymetry and Hydrodynamics

A detailed bathymetry survey of Village Harbor, was performed by eTrac Engineering, LLC (eTrac) on September 9 and 10, 2006. The resulting bathymetry is shown on Figure 1-3, and shows that the historic “sump area” visible in historical aerial photographs and topographic maps remains a topographic low. Water in the sump area is essentially isolated from Little Traverse Bay by a sill 8 to 10 feet high. This sill appears to prevent frequent mixing between bottom waters in the sump area and the overlying water of Village Harbor, allowing stagnation of bottom waters in the sump area.

As the bathymetric survey shows, Village Harbor is a relatively steep-sided and flat-bottomed feature with the sump area forming a pronounced topographic low in its central portion. Cobble-size limestone material or rip-rap material is present along much of the Harbor's perimeter.

In the southwest corner, geotechnical soil borings installed on land adjacent to the southwest corner indicated that there may be a "trough" feature present within the shallow bedrock in and near the southwest corner. This feature is likely a remnant of limestone mining and the trough has subsequently been partially filled, as discussed in Section 1.3.3.

Due to the limited fetch within the Harbor, there is little wind-driven wave generation and hence energy input to the harbor is low. Typical energy inputs into the Harbor include water surface variations within Little Traverse Bay, waves within Little Traverse Bay and waves generated within the Harbor itself by wind or boats. Water surface elevation changes in Little Traverse Bay can cause currents in and out of the harbor to equalize water surface elevation within the harbor, but these water surface elevation changes are relatively small and therefore are not likely to create significant flows within the harbor.

1.3.2 Water Column Samples

Results of water quality surveys conducted by Barr and by the United States Environmental Protection Agency (USEPA) have indicated elevated pH (greater than 9 s.u.) in some samples collected from the southwest corner of Village Harbor. The water column sampling conducted by Barr is summarized in the *Summary of Current Conditions/Work Plan for Village Harbor* (Barr. August 9, 2006). The water sampling indicates pH concentrations greater than 9.0 in some samples collected from the southwest corner at locations south of and adjacent to the boat dock located adjacent to the west shore of Village Harbor. The elevated pH readings were generally located within six inches to one foot from the sediment surface.

As summarized in the *Summary of Current Conditions/Work Plan for Village Harbor* (Barr. August 9, 2006), analytical results for water column samples within the harbor generally indicated relatively uniform distribution of the measured parameters throughout Village Harbor. The only metals detected were cations typically present in surface waters (cations calcium, magnesium, potassium, sodium, aluminum), as well as a low concentration of vanadium. Total Organic Carbon (TOC) concentrations were relatively uniform throughout the harbor, and concentrations of humic-range organic compounds (as indicated by the difference between preserved and unpreserved TOC) were low.

1.3.3 Sediment Characteristics and Composition

As summarized in the *Summary of Current Conditions/Work Plan for Village Harbor* (Barr. August 9, 2006), electron microprobe analysis indicated that the major constituent of all Village Harbor sediment samples was calcium carbonate. Sediment carbonate concentrations ranged from 37.4 to 50.0 percent by weight.

Distinctive sediment characteristics were noted in the southwest corner of Village Harbor. The sediment in this area consisted of light-colored fine-grained sediment, with calcium carbonate ($CaCO_3$) concentrations as high as 95 percent by weight. Based on the composition of the sediment in the southwest corner, calcium carbonate precipitate in the southwest corner appears to be occurring as a result of mixing of calcium-poor, carbonate-rich water with relatively calcium-rich surface water from the harbor.

To further evaluate sediment characteristics in the southwest corner, BBL recorded the completion of three soil borings in the southwest corner performed using a barge-mounted drilling rig. The methods and results of the soil boring investigation are summarized in Appendix B. The soil borings (locations are shown on Figure 2 of Appendix B) were advanced to refusal with a range of penetration below sediment surface (bss) of 4 to 12 feet.

Samples collected from boring BBL-01(06) showed cobble-size limestone pieces intermixed with reactive material (based on observed elevated field pH readings from a mix of the samples with tap water). However, a distinct reactive material layer was not identified. Samples collected from borings BBL-05(06) and BBL-06(06) also showed cobble-size limestone pieces intermixed with reactive material to approximately 2 feet bss; although below this layer, at approximately 2 feet bss, a more distinct reactive material layer was identified. The 2- to 4-foot interval sample from BBL-05(06) also contained some sand and gravel intermixed with the reactive material. In boring BBL-06(06), gray sand and gravel intermixed with reactive material was encountered at approximately 6 feet bss. Although a soft surface sediment layer may be present in the southwest corner area based on descriptions provided in the Barr reports, this layer was not recovered in the split-spoon samples from any of the three borings.

pH values of the recoverable sediment from the 0 to 2 feet sample at borings BBL-01(06), BBL-05(06), and BBL-06(06) were 9.5, 9.9, and 10.2 s.u., respectively. The pH values in each of the borings from the southwest corner area increase with depth below each of these samples, suggesting higher content of reactive material with depth in the sediments surface.

On September 8 and 9, 2006, Barr collected 15 sediment samples from Village Harbor, and nine samples were transported through BBL to Materials Testing Consultants of Grand Rapids, Michigan for geotechnical testing. Testing performed on these samples included unconfined compressive strength (ASTM D 2166), slump tests (ASTM C 143), grain size (ASTM D 422), shear strength (ASTM D 3080), consolidation (ASTM D 2435) and bulk density (ASTM D 2937). A sample location map and the geotechnical laboratory reports are presented in Appendix C. The geotechnical test results indicate that the sediment is comprised of predominantly silt- and clay-size particles (generally over 90 percent passing the No. 200 sieve), with a small percentage of sand- and gravel-sized material. Dry densities ranged from approximately 21.0 to 81.1 pounds per cubic foot (pcf) and initial water content ranged from 40.0 to 259.5 percent. Wet densities ranged from 75.6 to 113.4 pcf. Direct shear testing performed on three samples indicated cohesive strength ranging from 0 to 111 pounds per square foot (psf) and an internal friction angle of 30.3 to 31.5 degrees. Unconfined compression testing performed on five samples indicated an undrained shear strength ranging from 0.34 to 1.15 pounds per square inch (psi), which is equivalent to approximately 49 to 166 psf. Consolidation testing performed on three samples indicated that the compression index ranges from 0.34 to 1.30. These results indicate that the sediment is a low-strength, compressible material that derives most of its strength from internal friction.

1.4 Conceptual Model

Results of the previous sediment investigations indicate that the subsurface materials in the southwest corner consist of a mix of cobble-size limestone pieces, fine-grained sediment, reactive material, and broken concrete mostly overlain by the soft sediment described above. This soft sediment is likely a secondary precipitate, which appears to be caused by contact between the lake water and the underlying reactive material. Some, but not all, of the soil borings conducted in the southwest corner indicated the presence of reactive material below the surface layer.

Surface water sampling has indicated pH measurements greater than 9.0 s.u. in some, but not all, water samples collected near the southwest corner. The elevated pH readings were generally located within six inches to one foot from the sediment surface.

The proposed removal action presented in this report is designed to address elevated-pH readings collected in the southwest corner through a limited removal, backfill, and cover of sediments that contain reactive material imparting elevated pH to surface waters in the southwest corner.

2. Selected Remedy and Performance Standards

Section 121(d) of CERCLA requires that Superfund remedial actions at least attain legally applicable or relevant and appropriate requirements (ARARs), both federal and state, unless they are waived under CERCLA 121(d)(4).The AOC requires that CMS perform all actions required pursuant to the Order in accordance with all applicable local, state, and federal laws and regulations except as provided in Section 121(e) of CERCLA, 42 U.S.C. §6921(e), and 40 CFR §300.4000(e) and 300.415(j). The Order requires that CMS identify the specific ARARs for the Site under federal law. The objective of this section is to identify the substantive requirements based on federal and state requirements, as well as the location-specific, action-specific, and chemical-specific ARARs and how these ARARs will be addressed by the selected remedy.

2.1 Compliance with ARARs

Site ARARs were evaluated in the *Village Harbor Proposed Removal Action Alternatives Report, Southwest Corner* (CMS, November 7, 2006), and a summary of the ARAR evaluation is reproduced in this section. The identification of ARARs was performed to establish those state and federal regulations that are potentially applicable to the investigation and the remediation of a site.

ARARs for this Removal Action Work Plan include the substantive requirements of the MDEQ and United States Army Corner of Engineers (USACE) Joint Permit, including the following relevant substantive State and Federal requirements (not all of the requirements of the Joint Permit are relevant to this Removal Action Work Plan). Substantive relevant State requirements flow from Michigan's Natural Resources and Environmental Protection Act , 1994 PA 451 as amended (NREPA).

Federal Requirements:

- The Nationwide Permit 38
- Section 10 of the 1899 Rivers and Harbors Act
- Section 404 of the 1977 Clean Water Act

State Requirements:

- Part 325, Great Lakes Submerged Lands

- Part 31, Water Resources Protection
- Part 91, Soil Erosion and Sedimentation Control (SESC)
- Part 201, Environmental Remediation

2.1.1 Location-Specific ARARs

Location-specific ARARs are those that generally restrict certain activities or limit concentrations of hazardous substances solely because of geographical or land use concerns. The only identified location-specific ARAR is the location of the project area within the "Property" identified in the AOC, signed February 2005. The selected remedy is compliant with the AOC as site security and access restrictions are currently in place in the southwest corner area and access restrictions will be maintained until the completion of the remedial action.

2.1.2 Action-Specific ARARs

Action-specific ARARs are those that may place restrictions on the conduct of remediation activities or the use of certain technologies. Action-specific ARARs for the proposed work include:

- Nationwide Permit 38, NREPA Part 325, and NREPA Part 31 requirements related to permits for activities that occur below the Ordinary High Water Mark (OHWM) or the 100-year floodplain, respectively. The substantive requirements of these permits are documentation of excavation and fill activities. The proposed construction will not result in bottom contours at higher elevations than exist currently, no permanent structures (other than backfill material) will be installed, crane mats will be used to reduce shoreline disturbance if necessary, and appropriate shoreline stabilization measures will be installed, satisfying these ARARs.

- Nationwide Permit 38 and NREPA Part 91 SESC requirements address soil erosion and sedimentation issues. Compliance with SESC permit requirements will be achieved through the use of temporary erosion and sedimentation control measures during and following construction. Installation of a turbidity barrier around the excavation area will minimize impacts to surface water quality outside the excavation area.

2.1.3 Chemical-Specific ARARs

- Nationwide Permit 38 (and included regulations) and NREPA Part 31 address water quality impacts of construction projects. The erosion and sedimentation control measures which will be employed during construction activities will provide for minimal impact to surface water quality (satisfying a provision of the Nationwide Permit 38 pertaining to Section 401 Water Quality Certification). As described in Section 4.7, water quality monitoring will be performed for turbidity and pH outside the turbidity barrier during construction activities to assess the effectiveness of these measures.

  NREPA Part 31 R 323.1092 states that water quality standards will apply for disposal of dredge spoils in unconfined waters of the State. For this remedial action, dredge spoils will be dewatered and removed from the Site. Therefore this portion of R 323.1092 is not applicable because no dredge spoils will be returned to unconfined waters of the State.

  Temporary exceedances of water quality standards within the enclosed area during removal are unavoidable and are expected to occur. However, surface water quality criteria within the limits of excavation are not considered ARARs based on the numerous precedents for such projects approved by the USEPA and the State of Michigan. NREPA Part 31 R 323.1092, “Applicability of water quality standards to dredging or construction activities” states that water quality standards shall not apply to dredging or construction activities when the activities are authorized by the USACE. This project will not commence until USACE concurrence has been obtained. The remedial action as designed satisfies ARARs pertaining to surface water quality.

- Water quality impacts associated with placement of fill material is also an ARAR under Section 404 of the Clean Water Act (and included regulations) and NREPA Part 31. Clean earthen materials and engineered fill materials will be used for backfill in the removal area.

- Part 201 of Michigan NREPA, Environmental Remediation: construction workers involved in the excavation are potentially exposed to reactive materials such as CKD. Exposure to CKD and other reactive materials is addressed through the HASP and the project approach. The selected remedial action also meets the criteria of R 299.5730, which applies to surface water and sediments. Specifically, Subpart O prohibits “unacceptable risk to human contact". The remedial action will achieve compliance with the standards by preventing direct contact with elevated-pH water and sediment through the removal of the sediment and placement of an engineered cover over residual material.

2.2 Summary of Remedy Components

The major components of the selected remedy, sediment removal with engineered cover over residuals, include the following:

- Removal of approximately three feet of sediment over an approximately 65-foot by 35-foot area in the southwest corner of Village Harbor along the existing submerged slope (southwest corner area), removal of two feet of sediment in an area of approximately 80 feet by 35 feet located immediately north of the southwest corner (beach restoration area), and removal of two feet of sediment in an area of approximately 60 feet by 30 feet in the vicinity of the "horseshoe-shaped" dock (dock area).

- If, after the removal of three feet of sediment in the southwest corner area, reactive material is observed at the bottom of the excavation at any excavated location, up to two additional feet of sediment may be removed, for a total excavation depth of up to five feet. Additional removal will be performed only if a slope stability analysis indicates that the additional removal can be performed with an adequate factor of safety.

- Onsite gravity drainage of the excavated material in a lined and bermed staging area. The excavated sediment may be allowed to drain within roll-off containers or may be placed directly on the staging area. Once the excavated material has dewatered sufficiently to allow off-site transport (i.e., material passes paint-filter test), the material will be transported to an off-site Class II landfill for disposal.

- The staging/dewatering area will be graded to drain toward a collection sump and use natural filtration by sand and straw bales (or equivalent fibrous material) to remove fines from any decant water or stormwater that drains from the area. The decant water or stormwater that accumulates in the collection sump will be tested for pH and turbidity prior to being pumped into the harbor within the area enclosed by the turbidity barrier. If necessary, pH adjustment or filtration will be performed in the collection sump as described in Section 4.5 if the decant water has a pH of greater than 9 s.u. or turbidity greater than 25 nephelometric turbidity units (NTU).

- Placement of an engineered cover over the residual materials in the excavation area, which will also restore the lake bottom to its approximate original elevation. The cover will consist of the following materials, ordered from top to bottom:

    - Shoreline rip rap (D_{50} greater than 4½-inches) in the area south of the residential property, extending from an elevation of 576 feet to an elevation of approximately 579 feet at the toe of the bank.

    - Minimum one-foot thick gravel bioturbation layer in the southwest corner and dock area with a minimum one-foot thick sand layer underlying the gravel cover.

    - Minimum two-foot thick sand cover in the beach restoration area from an elevation of 569 feet to an elevation of approximately 578 feet adjacent to the edge of the lawn of the residential property.

    - Geosynthetic clay liner (GCL), to be installed under the upper two feet of cover material in all areas.

    - Mixed granular fill below (e.g., sand) the GCL in the southwest corner area to provide a base for placement of the GCL and provide a thickness sufficient to restore the excavation area to approximately two feet below its original elevation (approximately 0 to 3-foot thick layer of granular fill, depending on total depth of material removed).

- Post-construction monitoring for pH will be conducted quarterly at locations over and around the edges of the residuals cover placed in the southwest corner, beach restoration area, and dock area. Post-construction monitoring will be performed as described in Section 4.9.

3. Project Organization

The anticipated project organization, including key personnel and descriptions of duties and responsibilities for the RA program, is provided below.

3.1 USEPA

USEPA will serve as the lead regulatory agency for implementation of the removal action. If field conditions observed at the Site at the time of construction warrant modifications to the proposed Removal Action, USEPA may be consulted on field decisions. The USEPA Project Manager will be responsible for providing and coordinating regulatory oversight and direction.

3.2 MDEQ

MDEQ will provide guidance on this Removal Action Work Plan with regard to sediment and water management issues.

3.3 ARCADIS

ARCADIS will provide any additional design for the selected remedy not included in this Removal Action Work Plan and prepare final design deliverables if necessary.

ARCADIS will implement Removal Action activities for the southwest corner. ARCADIS will provide full-time engineering observation services for the duration of the removal activities to document that activities are conducted in accordance with this Removal Action Work Plan and associated plans submitted by the Remediation Contractor. ARCADIS will certify that the construction was completed in substantial conformance with the approved Removal Action Work Plan, and/or approved field changes. In addition to oversight and final engineering certification, ARCADIS will produce the site-specific HASP for the project.

3.4 Remediation Contractor

The Remediation Contractor selected for this project will provide services associated with sediment dewatering area construction, support facilities and access road construction, sediment excavation, cover placement, water monitoring, emergency spill response services (if necessary), and management of waste transport and disposal.

The Remediation Contractor may retain various subcontractors to complete the project, if necessary.

4. Removal Action

The general Removal Action tasks and the specific activities involved with implementing the selected remedy are described below.

4.1 Major Construction Tasks

More detailed information on the construction tasks and other related field activities, including quality control measures and post-remediation monitoring is provided in the following sections. These activities include the following:

- Mobilization and Site Preparation
- Turbidity Barrier Installation
- Sediment Excavation and Dewatering
- Residuals Cover Construction
- Construction Monitoring
- Decontamination and Site Restoration
- Post-Construction Monitoring

Prior to implementing the Removal Action, ARCADIS will procure a Removal Action contractor (Contractor) to perform the work and will provide an on-site representative throughout the Removal Action to observe and document the remedial activities.

4.2 Pre-Mobilization Activities

Before mobilizing to the Site, several activities will need to be completed, including obtaining the necessary permits, establishment of survey control and location of key features, clearing utilities, and preparing/submitting the required pre-mobilization submittals. These activities are discussed in more detail below.

4.2.1 Permits and Approvals

Consistent with the CERCLA Section 121(e)(1), because all removal activities will be conducted on-site and consistent with the AOC, permits are not required. Substantive requirements will be achieved to the extent practicable, consistent with this Work Plan.

4.2.2 Baseline Survey

A State of Michigan-registered professional surveyor will complete a pre-excavation survey to perform a general site layout using State Plane or International Great Lakes Datum (IGLD) coordinates and verify and stake out the excavation, sediment staging area, or other engineering control limits. The surveyor will record existing elevations at the provided control points. All control points will be maintained during the Removal Action, and control points that are damaged or removed during the Removal Action will be re-established promptly.

4.2.3 Utility Clearance

Prior to commencement of construction activities, the Contractor shall notify Michigan's One-Call Utility Notification Organization, and on-site underground utilities will be marked in the work areas. Underground and above ground utilities that could affect or be affected by construction activities will be identified prior to the initiation of intrusive soil activities. Locations of the utilities will be marked out by each utility company or their independent contractor. When utility locations are identified, the utility companies will review the locations and determine if the utilities will conflict with the proposed construction plans. If utility conflicts are identified, the Contractor and the appropriate utility company will discuss the actions required to resolve the conflict.

4.3 Mobilization and Site Preparation

Prior to initiating construction, the Contractor will perform mobilization and site preparation activities. At a minimum, it is anticipated that the following site preparation remedial activities will be performed:

- Verify existing site condition, conduct pre-mobilization site inspection, and locate all water intake and outfall pipes located in the future sediment removal area.

- Mobilize personnel, equipment and materials to the Site.

- Install temporary construction fencing or barriers as necessary to protect and secure the work area.

- Establish erosion and sedimentation control measures, including temporary re-routing of cooling water/surface drainage water outfall pipes and surface water intake pipes to outside the work area if necessary.

- Construct temporary access roads (as needed) for ingress and egress of construction equipment as well as off-site transportation of excavated materials.

- Prepare equipment decontamination area.

- Install a turbidity barrier around the sediment removal area.

- Construct a staging area for temporary placement of containers holding sediment during dewatering, or for direct placement of the sediment. This area will be lined with a synthetic liner.

- Construct a temporary working platform a safe distance from the shoreline to provide a level and stable working area for a crane to remove and replace containers from the barge, if applicable.

4.4 Turbidity Barrier Installation

A turbidity barrier will be installed around the perimeter of the excavation area, as shown in Figure 4-1. The turbidity barrier will consist of a curtain of impermeable polyvinyl chloride (PVC)-coated polyester base fabric suspended from the water surface with 8-inch diameter floats and anchored to the sediment surface using a galvanized steel ballast chain connected to the bottom of the turbidity barrier. The turbidity barrier will be anchored to the shore at each end of the excavation area.

Exchange of water across the turbidity barrier is expected to be predominantly inward due to the removal of material from within the area enclosed by the turbidity barrier. Cooling water/surface drainage water outfall pipes are present within the area to be enclosed by the turbidity barrier, and these pipes will be re-routed around the work area. Sand bags will be used to create a sump at the outfall discharge point, and water will be pumped from this point to a discharge point outside the enclosed area.

The southwest corner of Village Harbor is typically characterized by quiescent water. However, small waves in the harbor and water level changes on Little Traverse Bay may impart forces on the turbidity barrier. The effectiveness of the turbidity barrier could potentially be impacted by turbulence caused by storm water discharge (at a discharge point outside the turbidity barrier), wind, or boat traffic. Storm water discharge or windy conditions affecting the turbidity barrier will be temporary in nature, and no boat traffic is anticipated in Village Harbor during the remediation work.

The turbidity barrier will be inspected twice daily throughout the duration of the remediation work. In addition, field measurements of the surface water pH and turbidity outside the turbidity barrier will be collected as described in Section 4.7 to monitor the effectiveness of the turbidity barrier.

4.5 Sediment Excavation and Dewatering

Sediment excavation will be performed in the areas identified on Figure 4-1, utilizing an excavator or similar equipment operating from a barge or from a constructed platform. Excavation from the top of bank using an extended-reach excavator was evaluated and determined to be potentially unsafe. The analysis performed for this scenario is described in Section 4.6.4.1 and would apply to some, but not all, areas located along the immediate top of bank. Excavation from the bank may still be possible with constructed pads or crane mats placed at a distance from the excavation slope. If this approach is proposed by the selected contractor, stability analyses will be performed to evaluate the safety of the approach prior to implementation

Excavation will begin near the water’s edge and progress across the bank and then down the slope, with approximately three feet of sediment/bank material removed in the southwest corner area and approximately two feet of sediment removed in the beach restoration and dock areas. Excavation will be performed at a 1 horizontal to 1 vertical slope (1:1), unless otherwise determined as unsafe during the detailed design phase.

If reactive material is encountered in the southwest corner area during excavation, up to two feet of additional excavation may be performed in the area if a slope stability analysis indicates that the additional removal can be performed with an adequate factor of safety. Reactive material will be identified through visual observation and mixing sediment samples with distilled water and recording the pH of the mixture.

The estimated volume of sediment to be excavated is approximately 580 to 730 cy, subdivided into three areas as follows:

- Southwest corner area – 220 to 370 cy, depending on the depth of excavation
- Beach restoration area – approximately 230 cy
- Dock area – approximately 130 cy

The material removed will be deposited into containers constructed with a drainage collection system in the bottom or placed directly in a lined staging/dewatering area constructed near the top of bank. If containers are utilized, a geotextile will be placed in the container prior to placing sediment in the container to provide filtration. As containers fill, they will be removed by a crane operating from a pad constructed on the bank. The containers will be placed in a temporary staging/dewatering area constructed near the equipment pad, as shown on Figure 4-1. The sediment will be allowed to consolidate within the containers and free water will be drained, after which a paint filter test will be performed. If the material requires stabilization prior to transport, it will be mixed with a water-absorbing amendment such as saw dust, straw, wood chips, etc. by adding the material to the container and mixing.

If the material removed is deposited directly onto a staging/dewatering area, the area will be constructed with perimeter berms, an impermeable liner and overlying sand drainage layer. The staging/dewatering area will be approximately 30 feet by 50 feet and will be graded to drain toward a collection sump. The staging area is shown in plan view on Figure 4-1, and a cross section through the staging area is shown on Figure 4-2. The staging area will use the filtration of the sand drainage layer and natural filtration (i.e., straw bales or equivalent) at the lowest point of drainage to remove fines from any decant water or stormwater that drains from the area. The filtered water will drain to a collection sump area sized to accommodate the volume of water expected from an estimated daily production rate of 200 cy of sediment. Based on the geotechnical test results obtained for water content of the sediment, this volume of water is estimated to be less than 5,000 gallons per day. Therefore, a sump with dimensions of 30 feet long by 7 feet wide by 4 feet deep will be constructed adjacent to the staging area to accommodate approximately 5,000 gallons per day of water.

The decant water that accumulates in the sump will be tested for pH and turbidity prior to being returned to the harbor. Turbidity is being tested as a proxy for total suspended solids (TSS) that can be monitored in real-time in the field. If the pH is 9 s.u. or higher or the turbidity exceeds 25 NTU, the decant water will be treated to lower the pH into the range of 6 to 9 s.u. or the turbidity below 25 NTU as appropriate prior to discharge. Measures to reduce the pH or turbidity may include acid dosing of decant water within the sump withdrawing water from the sump to a water mixing tank for pH adjustment, or TSS removal via bag filtration or addition of an approved water treatment polymer. After the water meets the discharge criteria of 25 NTU and pH in the range of 6 to less than 9, the water will be pumped into the harbor within the area enclosed by the turbidity barrier.

Stormwater that contacts the sediment will also drain to the sump and will be analyzed for TSS and pH prior to discharge to the harbor. A two-inch rainfall would result in approximately 1,870 gallons of water potentially draining to the 5,000-gallon sump from the 1,500 square foot staging area.

Dewatered sediment will be tested using the paint filter test. If the sediment has sufficiently dewatered to pass this test, it will be loaded into sealed roll-offs or trucks with lined beds and hauled off-site to a Type II landfill (Waters Landfill in Waters, Michigan) for disposal by a licensed waste transporter. All sediment disposed off-site will be documented by a waste manifest and gate receipts for the tonnage received at the landfill.

4.6 Residuals Cover and Final Elevations

Following excavation of sediment and/or bank material from the southwest corner, beach restoration area, and dock area, the remaining residuals (if any) will be covered to provide isolation and separation of the residual material from the surface water in the harbor. The material isolation and separation will be provided through the installation of a combination low permeability and granular material cover comprised of the following components (from top to bottom):

- Shoreline rip rap (D_{50} greater than 4½-inches) in the area south of the residential property, extending from an elevation of 576 feet to an elevation of approximately 579 feet at the toe of the bank.

- Minimum one-foot thick gravel bioturbation layer in the southwest corner and dock area with a minimum one-foot thick sand layer underlying the gravel cover.

- Minimum two-foot thick sand cover in the beach restoration area from an elevation of 569 feet to an elevation of approximately 578 feet adjacent to the edge of the lawn of the residential property.

- Geosynthetic clay liner (GCL), to be installed under the upper two feet of cover material in all areas.

- Mixed granular fill below (e.g., sand) the GCL in the southwest corner area to provide a base for placement of the GCL and provide a thickness sufficient to restore the excavation area to approximately two feet below its original elevation (approximately 0 to 3-foot thick layer of granular fill, depending on total depth of material removed).

This cover will be installed to replace the material removed, and the final surface will be at approximately the same elevations indicated on the current bathymetry. No increase will occur in the lake bottom elevation or shoreline elevation relative to pre-removal elevations. The cover will be constructed over the area shown on Figure 4-3.

Cross sections through the cover in the three areas, showing the approximate thickness and extent of each layer and final elevations, are shown on Figures 4-4 through 4-6. As indicated on these figures, an approximate two- to five-foot thick cover will be installed to replace the material to be removed, with a thickness of one to three feet of mixed granular fill undernearth the GCL in the southwest corner area, depending on the depth of the excavation. All cover construction activities will be performed in accordance with the detailed plans and specifications developed for the project.

4.6.1 Mixed Granular Fill

In the southwest corner area, mixed granular fill consisting of sand and gravel will be installed below the GCL and above the sediment in the amount necessary to return the sediment surface to its pre-excavation elevation, minus two feet. A geotextile layer will be installed between this mixed granular fill layer and underlying sediment to provide separation, prevent migration of fines from the sediment into the granular fill layer, and provide improved strength for bridging over the sediment. The mixed granular fill will be installed in thin lifts (of approximately 3 inches) over the entire surface area.

The thickness of the mixed granular fill will be from one to three feet, depending on the depth of excavation performed. The final surface of this fill will be no steeper than a 4 horizontal to 1 vertical (4:1) slope. During installation of this material, surface elevations will be monitored periodically to verify that the desired slope and material thickness is achieved.

4.6.2 Geosynthetic Clay Liner

The GCL, the low permeability component of the cover, will be installed to the limits indicated on Figure 4-3 for all three areas. The GCL will consist of a bentonite clay layer sandwiched between two nonwoven geotextile layers, needle-punched together to provide enhanced strength and containment of the clay. The GCL will be deployed in panels using a small barge with a spreader bar or by pre-cutting smaller panels and placing them by hand from boats. Formwork may also be used to lower the panels into place. The GCL will be positioned as it is lowered into place, and adjacent panels will be overlapped.

4.6.3 Sand and Gravel

The sand and gravel layers will provide increased separation between any remaining reactive material and surface water in the harbor. The sand will be installed in thin lifts of approximately three inches each to provide continued stage loading and gradual consolidation of any underlying soft sediment. A minimum thickness of one foot of sand will be installed over the entire area, and an additional foot of sand will be installed in the restored beach area. The sand will be installed using a spreader device (or similar equipment) mounted on a barge to disperse the sand through the water column. Sand layer elevations will be surveyed periodically to identify areas in need of additional fill.

The gravel layer will be installed in lifts of three to four inches and to a minimum of one foot in thickness. The gravel will extend over the entire cover area, with the exception of the restored beach area, and final elevation will match the existing bathymetry at the edges of the cover area. This layer will provide a bioturbation layer and protection against erosive forces from waves and boat propeller action. Based on the analysis for design of the armoring system, provided in Appendix D, a large gravel (e.g., D_{50} greater than ¾-inch) should be sufficient to provide protection against propeller action from small recreational watercraft in all areas where the harbor is at least 10 feet deep and boat traffic is anticipated. However, along shallow bank areas a small to medium rip rap (e.g., D_{50} greater than 4½-inches) is recommended if boats will be operating next to docks in less than 8 feet of water. Shoreline rip rap will also be installed over the gravel layer in the southwest corner area, to provide additional protection from wave action.

In addition to the other functions identified, the combined sand, gravel, and rip rap (where present) layers will provide ballast for the GCL installed below the sand layer, which may be subject to hydraulic uplift forces. Rip rap placed along the shoreline and bottom of slope area would also provide an improved factor of safety against slope instability, as described below.

4.6.4 Excavation and Cover Slope Stability Analysis Results

Slope stability analyses were performed for the bank slope with the excavation completed to a depth of three to five feet and for the cover system constructed as described in the previous section. The analyses were performed utilizing WinStabl (Bosscher, P. and Betkas, H., University of Wisconsin – Madison, 2001) to model potential circular and block failure modes for the short-term and long-term condition. This program calculates a factor of safety against instability of a slope using an adaptation of the Janbu and Modified Bishop Method (2-diminsional method of slices), which allows for analysis assuming surfaces of general shape. A factor of safety less than one indicates that failure is likely. For short term analyses, a factor of safety of 1.25 is acceptable, and for long-term analyses a factor of safety of 1.5 is considered acceptable.

4.6.4.1 Excavation Slope Stability

The general slope profile at the steepest (most critical) section was plotted with coordinates for input into the WinStabl program, along with the known and/or assumed stratigraphy. The soil strength parameters assigned to each soil strata included in the analyses for the bank excavation are presented in Appendix E.

Circular failure analyses were performed for the excavation slope with and without the surcharge loading of an excavator on the bank. For the cases with a long-reach excavator added, static loading was modeled. The static load used was the distributed load of a Caterpillar 385C L Hydraulic Excavator with a reach of 38 to 56 feet, depending on depth. This static load was equal to 5,080 pounds per square inch with heavy loading, and was placed near the top of the bank slope. This load is simply the dead weight of the equipment. As the equipment begins to move, it also introduces dynamic loading similar to the movement experienced during an earthquake which is modeled as horizontal acceleration equal to 0.1 times the force of gravity (0.1 g). The results of these analyses are summarized below on Table 1.

Table 1

Bank Excavation Slope Stability Results

Analysis Description	Load Imposed	Failure Mode	Most Critical FS	Comments
3' Deep Excavation	None	Circular	1.20	Acceptable, but lower than desired
Excavation Slope – Static Load	Excavator dead weight	Circular	0.77	Slope failure
Excavation Slope – Dynamic Load	Moving Excavator	Circular	N/A	Not analyzed since static load failed

The analyses are presented in Appendix E, and include a description of the input parameters and output files, and a graphical presentation of the ten most critical failure surfaces generated for each model run. The results indicate that the maximum excavation depth should not exceed three feet in the area analyzed, and a three-foot deep excavated slope will not fail provided heavy equipment is not operating just above the excavation. However, if a long-reach excavator is positioned to excavate from the bank, the weight and operation of the equipment will likely cause a slope failure and an unsafe condition. It is therefore recommended that excavation be performed from a barge using a smaller hydraulic excavator, or that equipment be sized with greater reach and located a greater distance from the top of slope if excavation from the bank is considered. For the latter case, stability analyses should be performed by the contractor for any configuration proposed with equipment operating on the bank before excavation is performed.

4.6.4.2 Cover Slope Stability – Short-Term Analyses

The same general slope profile and stratigraphy used for the excavation slope stability analyses, with the addition of the cover layers, was used to model the short-term stability of the slope following cover construction. Strength parameters assigned to each soil strata and cover layer are described in Appendix F.

Hundreds of trial failure surfaces were generated to evaluate the slope stability for block and circular surface failure modes. The ten most critical surfaces are presented graphically in Appendix F along with the input and output files for each model run. The most critical factor of safety for each failure mode is shown on Table 2 below.

Table 2

Southwest Corner Cover Slope Stability Results – Short-Term Analyses

Analysis Description	Most Critical FS	Comments
Block Failure	1.48	Acceptable
Circular Failure	1.20*	Lower than desired

*This failure surface is actually a failure through the natural bank slope rather than through the cover.

It should be noted that the most critical failure surfaces generated for the circular failure mode were failures within the natural topography just above the cover. Since the section modeled is of limited extent laterally, the severity of the slope at that location will be mediated by the gentler slopes located on either side of the steep area. The failure surfaces generated within the constructed cover had approximately a 1.5 factor of safety or higher, which is acceptable. If rip rap is placed along the toe and bottom of slope, it will increase the factor of safety against failure by providing more resisting force at the toe.

4.6.4.3 Cover Stability Analyses – Long-Term Analyses

Since long-term stress on the GCL could lead to creep deterioration of the needle-punched reinforcement fibers, the cover stability analyses were performed for the same cover profile and soil strengths assumed for the short-term analyses described in the previous section, with the exception that the GCL strength was reduced to zero cohesion and a residual friction angle of 8 degrees. Both circular and block failure surfaces were generated, and the ten most critical surfaces are presented graphically along with the safety factors achieved for each run in Appendix G. The results are summarized on the following Table 3.

Table 3

Southwest Corner Cover Slope Stability Results – Long-Term Analyses

Analysis Description	Most Critical FS	Comments
Circular Failure	1.41*	Lower than desired
Block Failure	1.74	Acceptable

*This failure surface is actually a failure of the natural bank slope rather than through the cover.

The most critical surface had a factor of safety of 1.41 in a circular mode, but this surface is associated with the local topographic feature noted previously. This localized section of steep slope (approximately 2:1) is of limited extent and is more severe than the adjacent slope areas. Therefore, most of the southwest corner area would likely have a factor of safety greater than 1.5 for this type of failure. The factor of safety for the most critical block failure surface was 1.74, and when the search was limited to the cover area only, the minimum factor of safety achieved was 2.37. These factors of safety are acceptable for the long term stability of the cover.

4.7 Construction Monitoring

During construction activities, surface water in Village Harbor will be monitored for pH and turbidity to assess the performance of the turbidity barrier, installed as described in Section 4.4. The surface water monitoring will occur at three locations immediately outside of the turbidity barrier. Samples will be collected at these locations twice daily (in the morning and afternoon) during work activities. Field measurements for pH will be conducted using a YSI 600R probe or equivalent. Turbidity monitoring will be performed using a Hach 2100P portable turbidimeter or equivalent. Samples will be collected from the mid-point of the water column at these locations.

If monitoring results indicate a pH greater than 9.0 s.u. or a turbidity of 25 NTU outside of the area enclosed by the turbidity barrier, an assessment will be performed to identify the cause of the monitoring result and identify corrective measures. If pH does not return to less than 9.0 s.u. or turbidity return to less than 25 NTU within three hours of the monitoring result, or if pH becomes greater than 10.0 s.u. or turbidity greater than 50 NTU, work activities will be suspended. Monitoring for pH and turbidity at these locations will continue, and work activities will not resume until pH is measured below 9.0 s.u. and the turbidity level is measured below 25 NTU at the monitoring location.

If elevated pH conditions persist outside the area enclosed by the turbidity barrier, additional measures may be taken in the work zone to reduce the pH of the surface water. These measures may include acid dosing of surface water in the work zone or withdrawing water from the area to a water mixing tank for pH adjustment and return of the water to the work zone.

4.8 Decontamination and Site Restoration

Decontamination of vehicles and equipment decontamination will consist of pressure washing the tires and wheel wells or tracks of the equipment. The sides of vehicles and equipment leaving the site will be visually inspected, and soiled equipment will be steam cleaned or pressure washed prior to the vehicle or equipment leaving the site. The wash water will be collected, filtered, and discharged to Village Harbor. Filtering will be performed using natural materials, such as filtering through straw bales or wood chips.

Following sediment excavation and covering activities, soil on the shoreline disturbed to create the sediment dewatering area and work platform will be re-graded to as close as practicable to its original elevation. If re-grading is insufficient to restore the original elevation of the shoreline areas, imported backfill will be placed and compacted to restore the ground surface within the shoreline area to approximate preremediation conditions. Ground surface restoration will include seeding of the disturbed areas.

Backfill from off-site sources will be sampled and analyzed to confirm that the proposed materials are free of contaminants and suitable for their intended use as backfill. At a minimum, proposed backfill and topsoil source(s) will be sampled and analyzed for volatile organic compounds, semi-volatile organic compounds, PCBs, pesticides, herbicides, and metals. In lieu of the analytical sampling and testing, the Contractor will be allowed to provide two copies of certified test results from a recent sampling event from the borrow source, or a certification from the borrow source that the material is virgin, uncontaminated material.

4.9 Post-Construction Monitoring

Post-construction monitoring will be performed quarterly following the completion of the remedial action. Twenty locations located over and around the edges of the residuals cover will be monitored for pH (Figure 4-7). Water samples will be collected from the lowest one foot of the water column and the middle of the water column at each monitoring location. If results of the field monitoring indicate any pH measurements greater than 9.0 s.u., step-out monitoring will be performed to define the limits of pH greater than 9.0 s.u..

Samples will be field-measured for pH (using a YSI 600R probe or equivalent). The results of the field monitoring will be reported to the U.S. EPA and the MDEQ within 30 days of each monitoring event. If the four quarterly monitoring events indicate that pH sample results are less than 9.0 s.u., post-construction monitoring will be discontinued. If the quarterly monitoring results indicate pH sample results greater than 9.0 s.u., an assessment will be performed to evaluate the source of the elevated pH. Results of the assessment will be used to develop an approach to address the pH results in consultation with the USEPA, which could entail further monitoring.

5. References

Barr Engineering (Barr). *Summary of Current Conditions/Work Plan for Village Harbor.* August 9, 2006.

Blasland, Bouck and Lee (BBL), an ARCADIS Company. *Supplemental Sediment Borings – Southwest Corner Area, Remedial Investigation, Village Harbor.* December, 2006.

CMS Land Company (CMS). *Village Harbor Proposed Removal Action Alternatives Report, Southwest Corner.* November 7, 2006.

United States Environmental Protection Agency (USEPA). *Administrative Order on Consent for Removal Action (AOC or Order) for the Little Traverse Bay (LTB) Cement Kiln Dust (CKD) Release Site (Site) (Docket No. VW-05-C-810).* February 22, 2005.

Figures

REFERENCE: BASE MAP USGS 7.5 MIN. QUADS., PETOSKEY, AND BAY SHORE MI, 1983.

2000' 0 2000'

Approximate Scale: 1" = 2000'

Area Enlargement

CMS LAND COMPANY
VILLAGE HARBOR, EMMET COUNTY, MICHIGAN
SW CORNER REMOVAL ACTION WORK PLAN

SITE LOCATION

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE 1-1

01/04/08 SYR/D85/DJH
22816/0000/00100/CDR/22816N01.CDR

0 100 200
Feet
GRAPHIC SCALE

NOTES:

1. AERIAL PHOTO COLLECTED IN APRIL 2005 PROVIDED IN GEOREFERENCED FORM BY BARR ENGINEERING, INC.

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VILLAGE HARBOR, EMMET COUNTY, MICHIGAN

SW CORNER REMOVAL ACTION WORK PLAN

SITE PLAN
VILLAGE HARBOR

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
1-2

SYR-85 MTK AMB
CMS Energy (22816.001)
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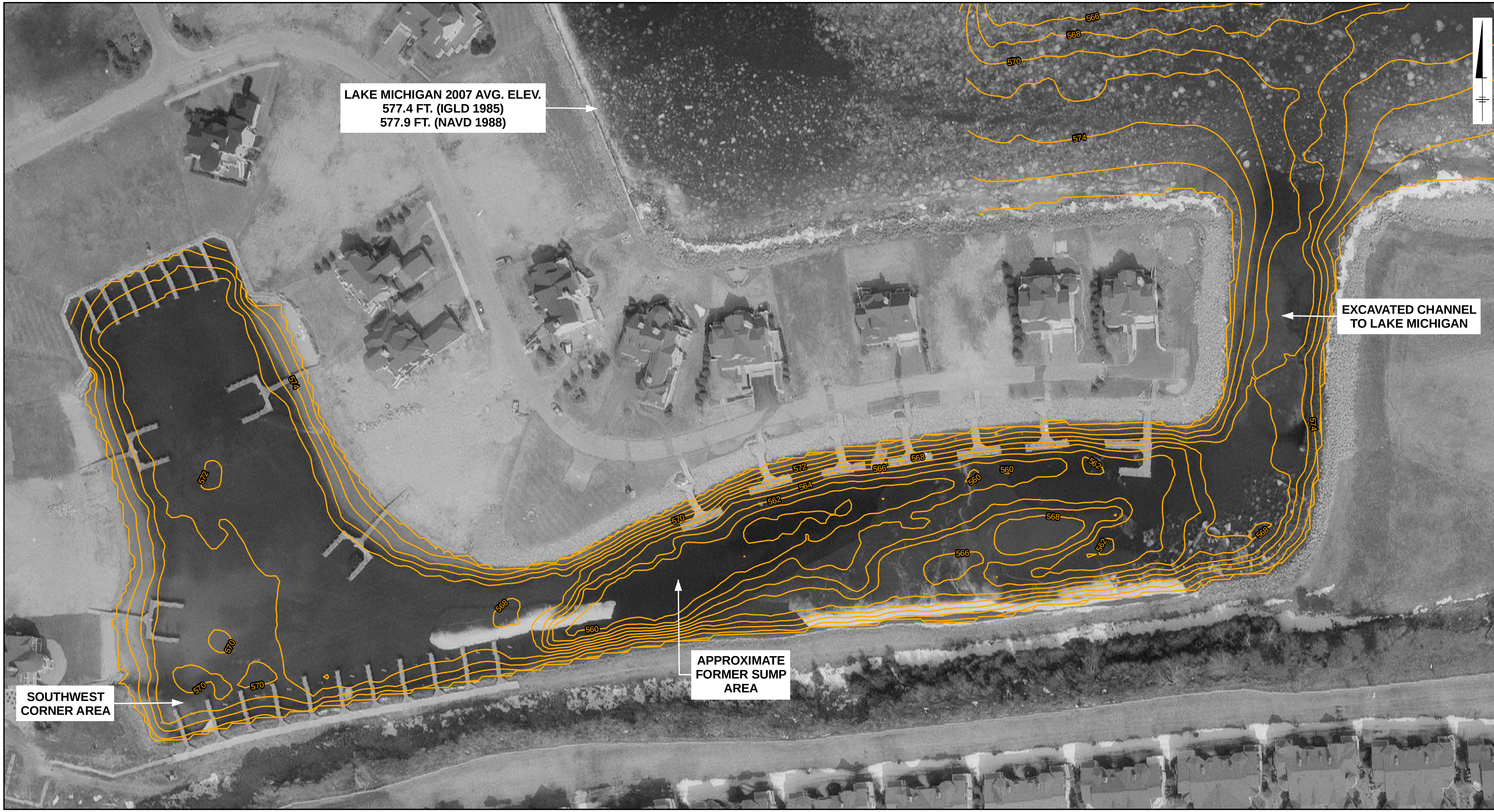

Legend

BATHYMETRY ELEVATION CONTOUR - 2 ft

0 100 200 Feet

GRAPHIC SCALE

NOTES:

1. AERIAL PHOTO COLLECTED IN APRIL 2005 PROVIDED IN GEOREFERENCED FORM BY BARR ENGINEERING, INC.
2. BATHYMETRY DATA ENTITLED 10ftSumpEleC.shp FROM BARR ENGINEERING, INC.
3. BATHYMETRY PERFORMED BY eTRAC ENGINEERING, LLC IN SEPTEMBER 2006.
4. VERTICAL DATUM IS NAVD88.

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SW CORNER REMOVAL ACTION WORK PLAN

VILLAGE HARBOR BATHYMETRY

ARCADIS BBL
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FIGURE 1-3

SYR-85 MTK AMB
CMS Energy (22816.001)
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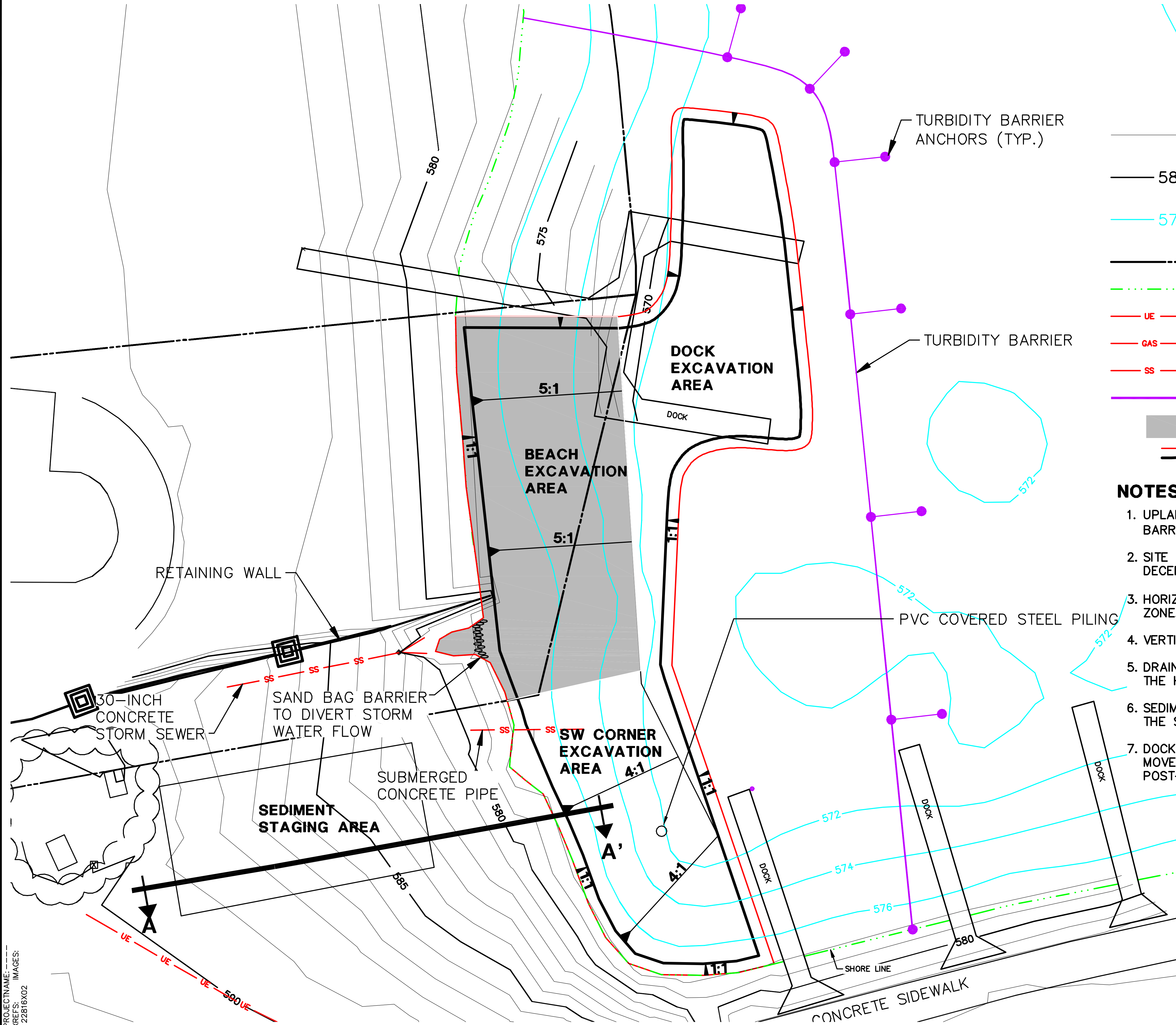

LEGEND:

	EXISTING INTERMEDIATE LAND CONTOURS (1 FOOT INTERVAL)
580	EXISTING INDEX LAND CONTOURS (5 FOOT INTERVAL)
572	EXISTING BATHYMETRIC CONTOURS (2 FOOT INTERVAL)
	PROPERTY LINE
	APPROXIMATE SHORELINE
UE — UE	UNDERGROUND UTILITY
GAS — GAS	GAS LINE
SS — SS	STORM SEWER
	TURBIDITY BARRIER
	BEACH RESTORATION AREA
	EXCAVATION AND PERIMETER SLOPE INDICATOR

NOTES

1. UPLAND TOPOGRAPHY AND OTHER BASEMAPPING PROVIDED BY BARR ENGINEERING DATED 10/3/2006, VILLAGE HARBOR 2006.dwg
2. SITE CONTROL IS BASED OFF AERIAL SURVEY COMPLETED IN DECEMBER, 2004.
3. HORIZONTAL DATUM IS NAD83/94 MI. STATE PLANE CENTRAL ZONE.
4. VERTICAL DATUM IS NAVD88.
5. DRAINAGE WATER FROM THE STAGING AREA WILL BE RETURNED TO THE HARBOR BY PUMPING OR VIA GRAVITY DRAIN PIPE.
6. SEDIMENT MAY BE DEWATERED IN CONTAINERS RATHER THAN ON THE STAGING AREA.
7. DOCK LOCATED IN DOCK EXCAVATION AREA WILL BE TEMPORARILY MOVED DURING CONSTRUCTION AND REPLACED POST-CONSTRUCTION.

0 20' 40'
GRAPHIC SCALE

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SW CORNER REMOVAL ACTION WORK PLAN

SEDIMENT EXCAVATION PLAN

ARCADIS
Infrastructure, environment, facilities

FIGURE
4-1

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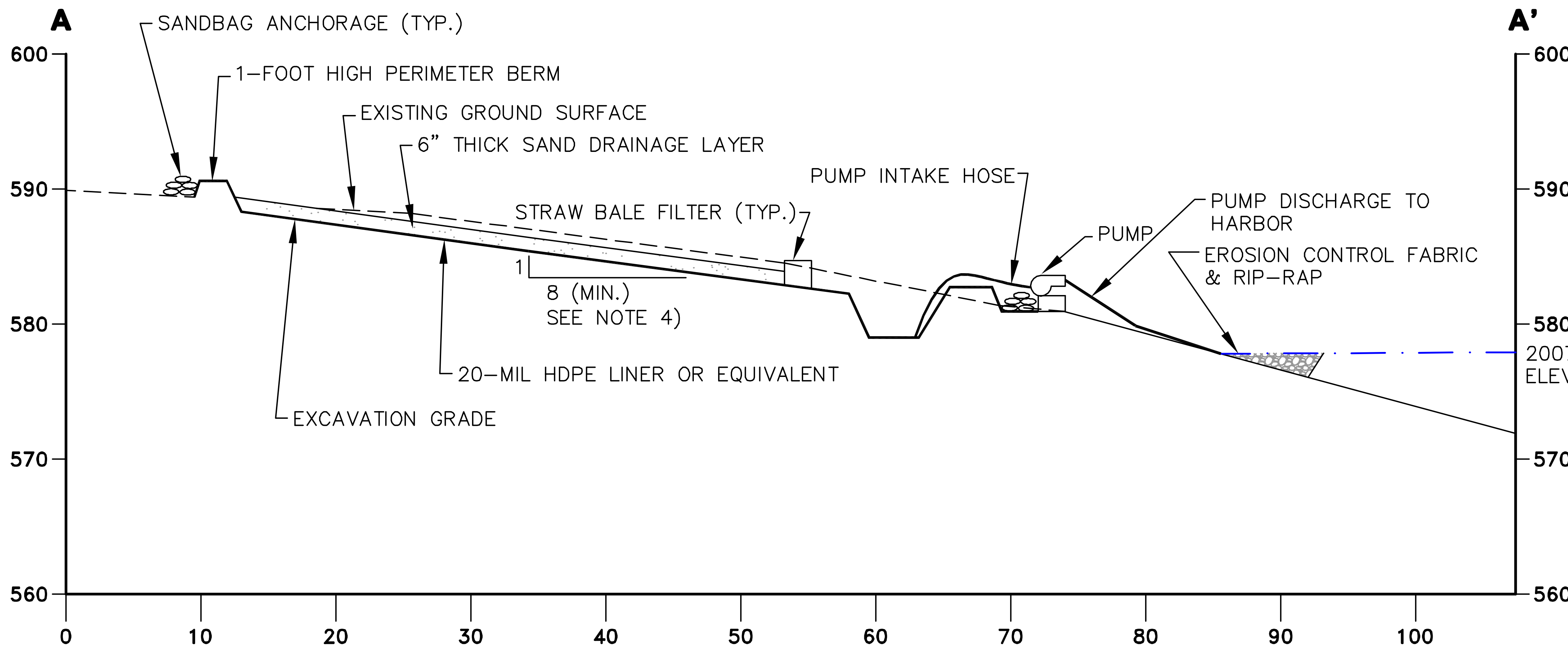

NOTE:

1. SEE FIGURE 4–1 FOR LOCATION OF CROSS–SECTION A–A'.
2. STAGING AREA SIZE AND DIMENSIONS WILL BE DETERMINED DURING THE DETAILED DESIGN PHASE. DIMENSIONS SHOWN HERE MAY VARY FROM THE FINAL DESIGN.
3. A GRAVITY DRAINAGE PIPE MAY BE UTILIZED IN LIEU OF THE PUMP TO RETURN WATER TO THE HARBOR.
4. BOTTOM SLOPE OF STAGING SLOPE AREA WILL BE NO STEEPER THAN 8 FEET HORIZONTAL TO 1 FOOT VERTICAL.
5. VERTICAL DATUM IS NAVD88.
6. SAND DRAINAGE LAYER TO BE DISPOSED OFF–SITE TOGETHER WITH DREDGED MATERIALS.
7. SEDIMENT MAY BE DEWATERED IN CONTAINERS RATHER THAN CONSTRUCTING A STAGING AREA.
8. AVERAGE LAKE ELEVATION OBTAINED FROM LUDINGTON AND MACKIMAW CITY GAUGE STATIONS. (WWW.CO–OPS.NOS.NOAA.GOV)

0 10' 20'
HORIZONTAL SCALE

0 10' 20'
VERTICAL SCALE

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VILLAGE HARBOR, EMMET COUNTY, MICHIGAN

SW CORNER REMOVAL ACTION WORK PLAN

SEDIMENT STAGING AREA CROSS-SECTION A-A'

ARCADIS
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FIGURE
4-2

BRI–85–ADF LAYER: ON=*, OFF=*REF*
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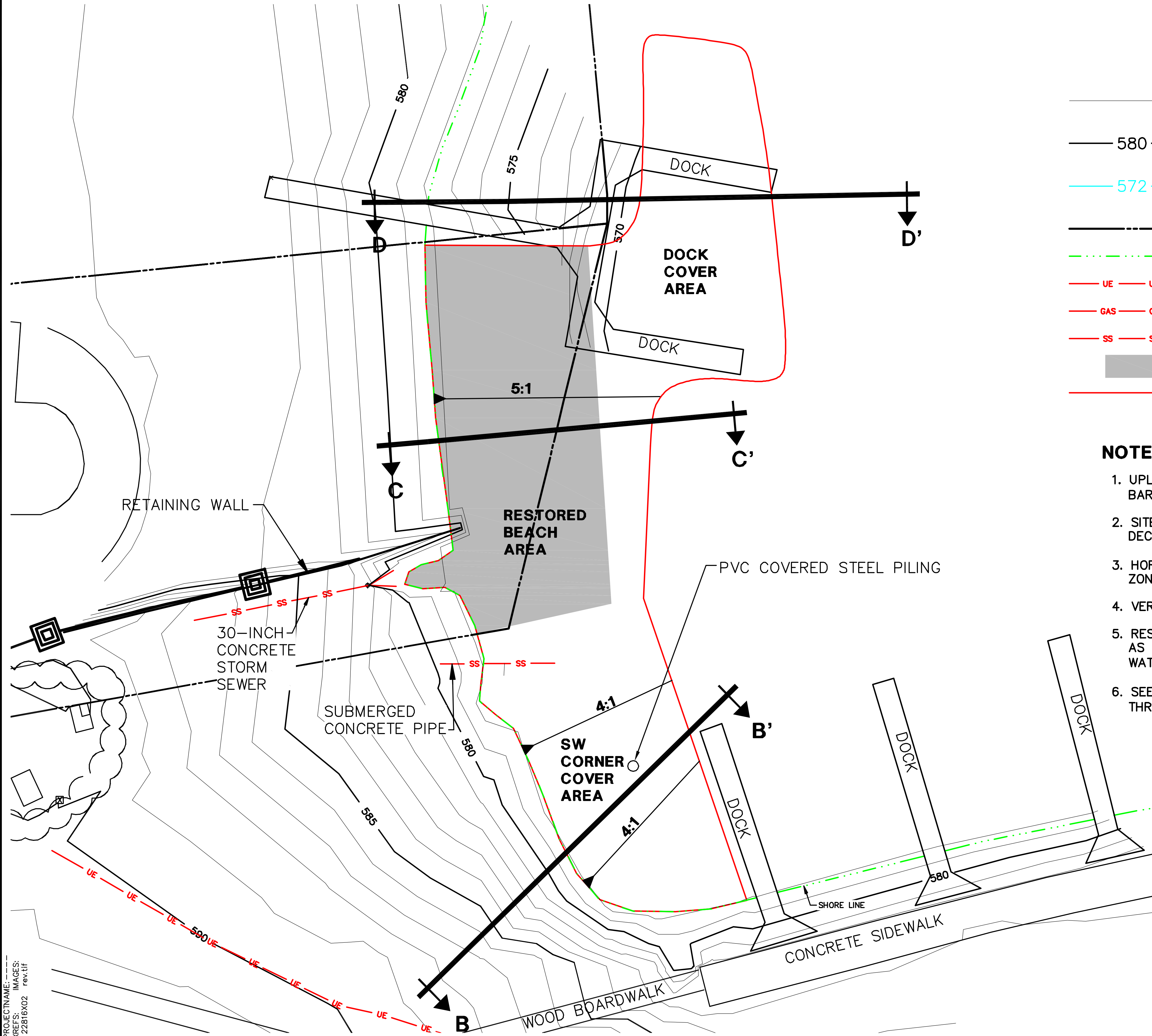


LEGEND:

	EXISTING INTERMEDIATE LAND CONTOURS (1 FOOT INTERVAL)
580	EXISTING INDEX LAND CONTOURS (5 FOOT INTERVAL)
572	EXISTING BATHYMETRIC CONTOURS (2 FOOT INTERVAL)
	PROPERTY LINE
	APPROXIMATE SHORELINE
UE — UE	UNDERGROUND UTILITY
GAS — GAS	GAS LINE
SS — SS	STORM SEWER
	BEACH RESTORATION AREA
	PERIMETER OF COVERED AREA

NOTES

1. UPLAND TOPOGRAPHY AND OTHER BASEMAPPING PROVIDED BY BARR ENGINEERING DATED 10/3/2006, VILLAGE HARBOR 2006.dwg
2. SITE CONTROL IS BASED OFF AERIAL SURVEY COMPLETED IN DECEMBER, 2004.
3. HORIZONTAL DATUM IS NAD83/94 MI. STATE PLANE CENTRAL ZONE.
4. VERTICAL DATUM IS NAVD88.
5. RESTORED BEACH AREA MAY EXTEND SAND COVER TO THE WEST AS NECESSARY TO MAKE AESTHETIC IMPROVEMENTS BETWEEN THE WATER LINE AND RESIDENTIAL PROPERTY'S LAWN LINE.
6. SEE FIGURES 4-4 THROUGH 4-6 FOR CROSS SECTIONS B-B' THROUGH D-D'.

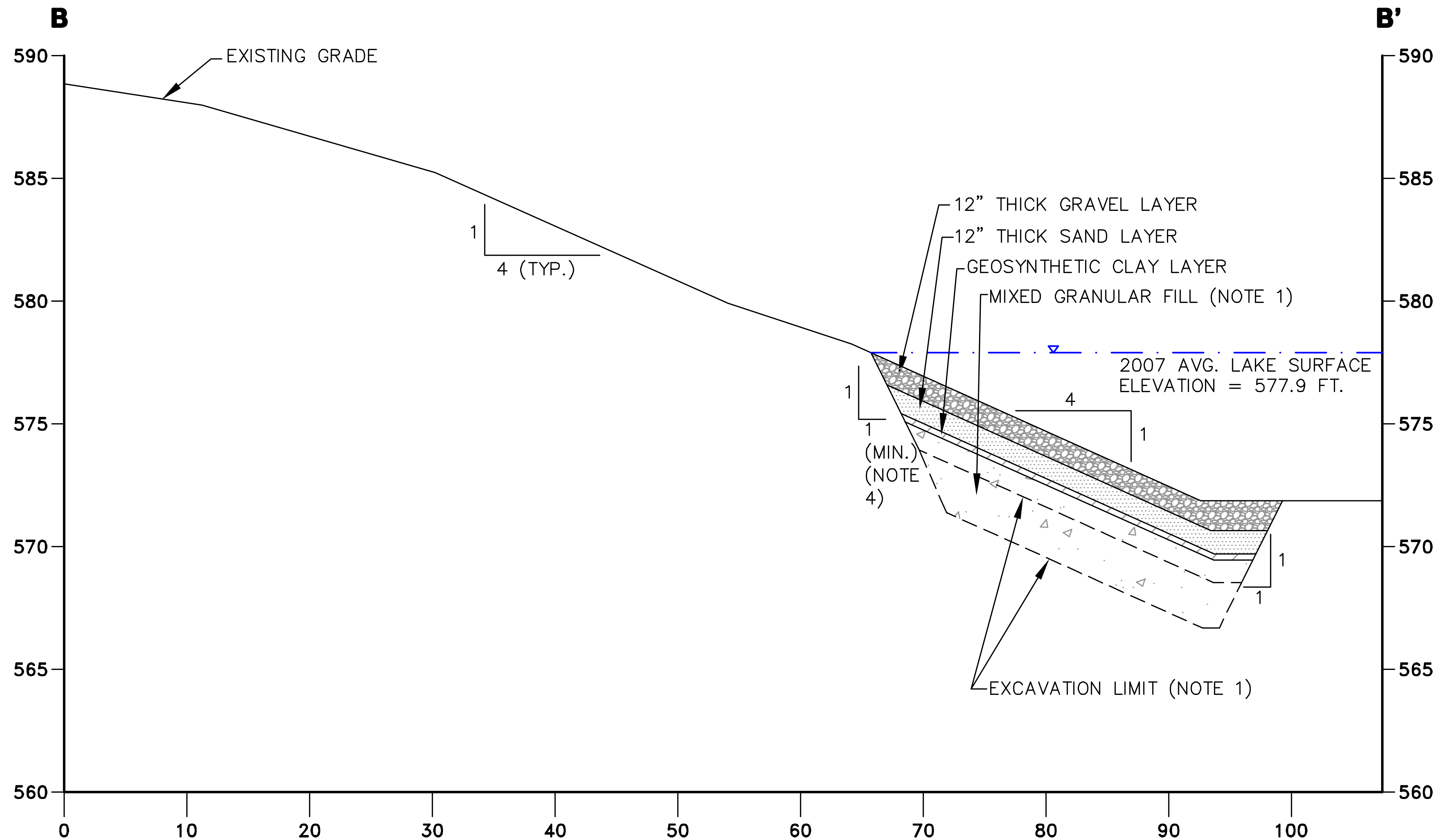
0 20' 40'
GRAPHIC SCALE

CMS LAND COMPANY
VILLAGE HARBOR, EMMET COUNTY, MICHIGAN
SW CORNER REMOVAL ACTION WORK PLAN

COVER PLAN VIEW

ARCADIS
infrastructure, environment, facilities

FIGURE
4-3



NOTE:

1. IF REACTIVE MATERIAL IS PRESENT IN THE SIDE SLOPE FOLLOWING THE INITIAL 3' DEEP EXCAVATION, AN ADDITIONAL 2' DEEP EXCAVATION MAY BE PERFORMED PENDING AN ANALYSIS OF SLOPE STABILITY. ONE TO THREE FEET OF MIXED GRANULAR FILL SHALL BE PLACED OVER THE FINAL EXCAVATION SURFACE.
2. VERTICAL DATUM IS NAVD88.
3. UPLAND TOPOGRAPHY AND OTHER BASE MAPPING WAS PROVIDED BY BARR ENGINEERING, DATED 10/3/2006, VILLAGE HARBOR.
4. EXCAVATION SIDE SLOPE WILL BE 1 FOOT HORIZONTAL TO 1 FOOT VERTICAL OR FLATTER DEPENDING ON CONDITIONS ENCOUNTERED DURING EXCAVATION.
5. SEE FIGURE 4-3 FOR CROSS-SECTION B-B'.
7. AVERAGE LAKE ELEVATION OBTAINED FROM LUDINGTON AND MACKINAW CITY GAUGE STATIONS. (WWW.CO-OPS.NOS.NOAA.GOV)

0 10' 20'
HORIZONTAL SCALE

0 5' 10'
VERTICAL SCALE

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SW CORNER REMOVAL ACTION WORK PLAN

COVER CROSS-SECTION B-B'

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FIGURE
4-4

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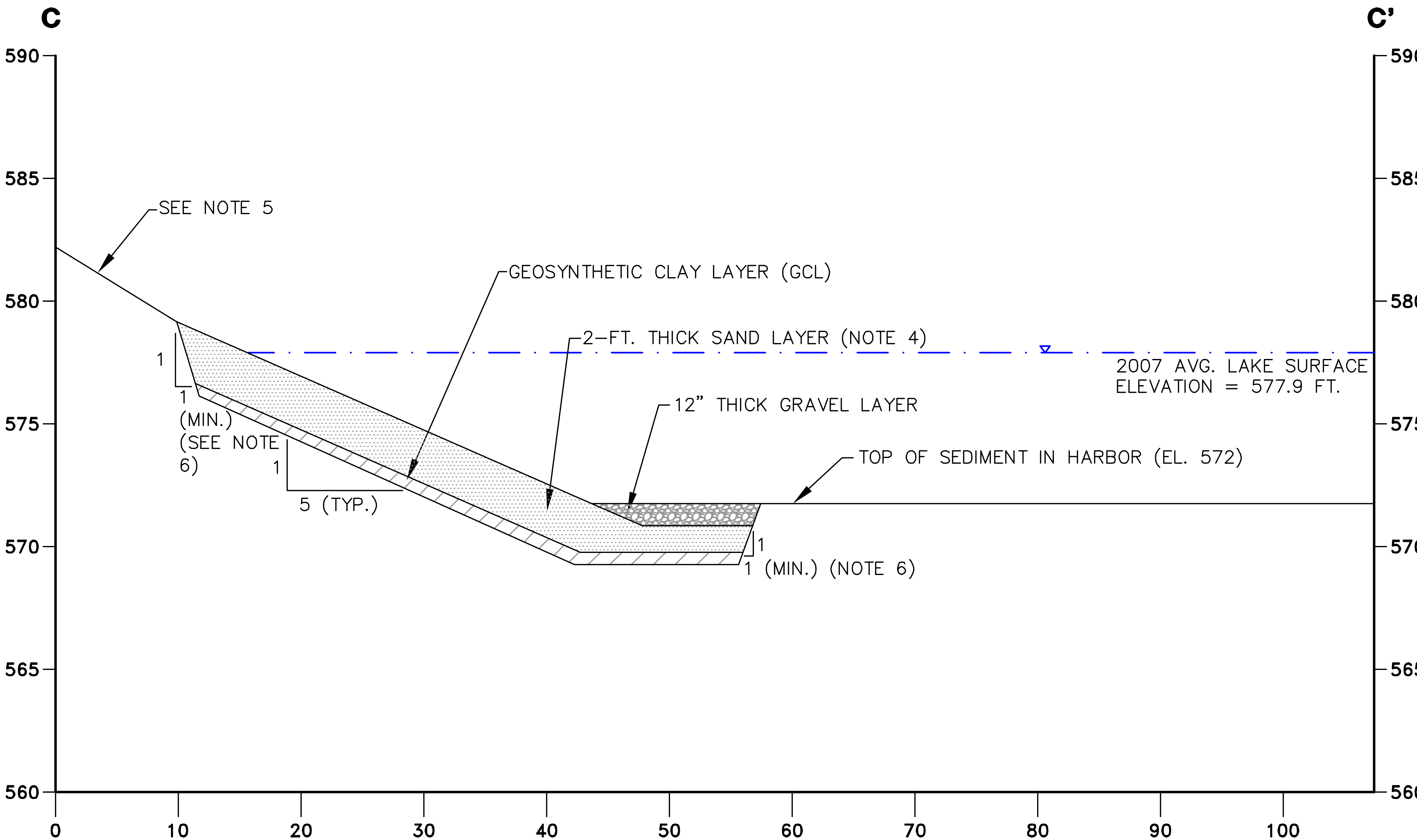


NOTE:

1. VERTICAL DATUM IS NAVD88.
2. UPLAND TOPOGRAPHY AND OTHER BASE MAPPING WAS PROVIDED BY BARR ENGINEERING, DATED 10/3/2006, VILLAGE HARBOR.
3. SEE FIGURE 4–3 FOR CROSS–SECTION C–C'.
4. TWO–FOOT THICK SAND LAYER SHALL BE PLACED OVER GCL IN AREA DESIGNATED AS "BEACH RESTORATION AREA".
5. RESTORED BEACH AREA MAY EXTEND SAND COVER TO THE WEST AS NECESSARY TO MAKE AESTHETIC IMPROVEMENTS BETWEEN WATER LINE AND RESIDENTIAL PROPERTY'S LAWN LINE.
6. EXCAVATION SIDE SLOPE WILL BE 1 FOOT HORIZONTAL TO 1 FOOT VERTICAL OR FLATTER DEPENDING ON CONDITIONS ENCOUNTERED DURING EXCAVATION.
7. AVERAGE LAKE ELEVATION OBTAINED FROM LUDINGTON AND MACKINAW CITY GAUGE STATIONS. (WWW.CO–OPS.NOS.NOAA.GOV)

0 10' 20'
HORIZONTAL SCALE

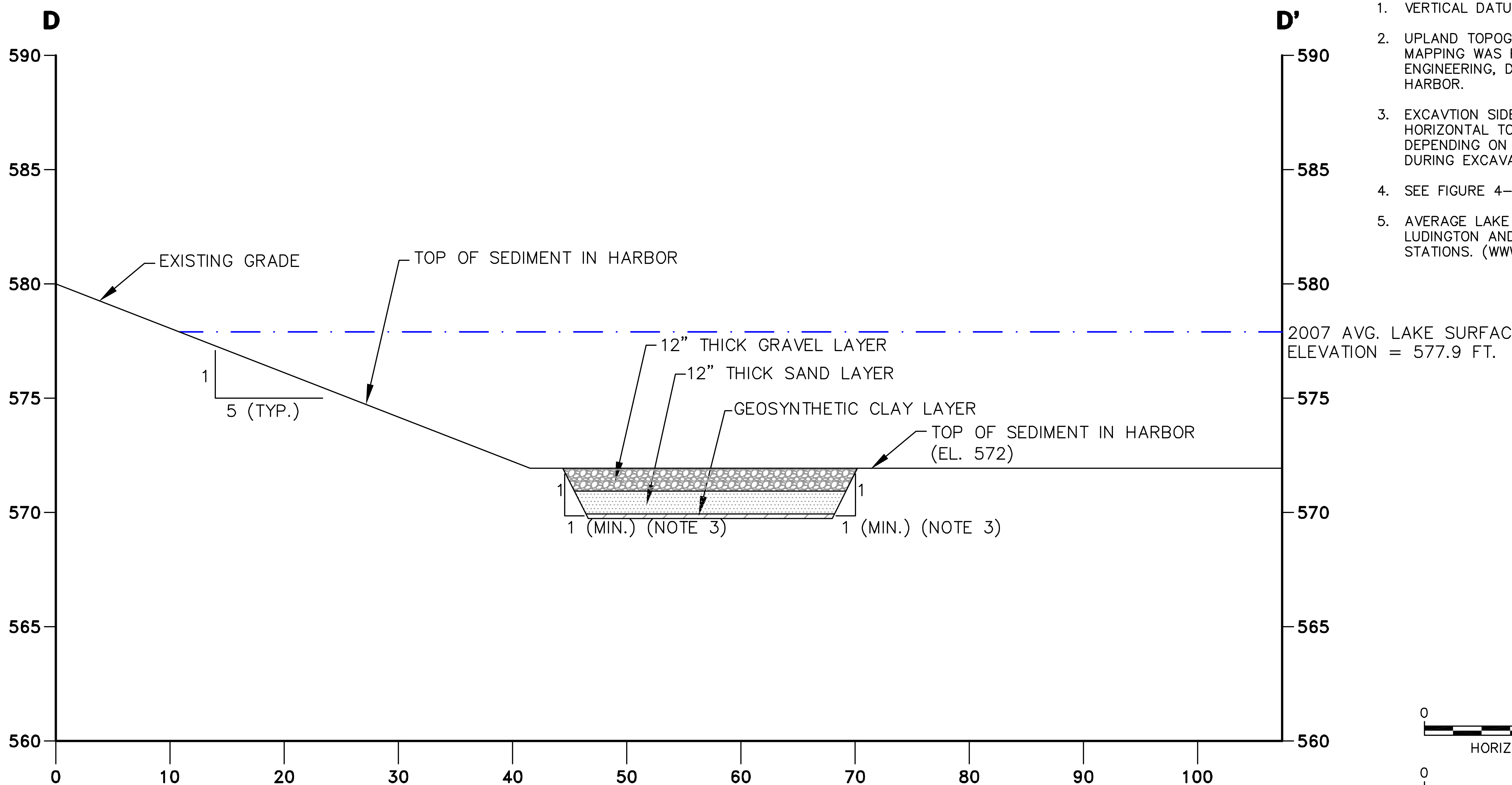
0 5' 10'
VERTICAL SCALE

CMS LAND COMPANY
VILLAGE HARBOR, EMMET COUNTY, MICHIGAN
SW CORNER REMOVAL ACTION WORK PLAN

COVER CROSS-SECTION C-C'

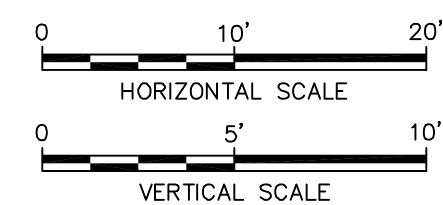
ARCADIS
Infrastructure, environment, facilities

FIGURE
4-5



NOTE:

1. VERTICAL DATUM IS NAVD88.
2. UPLAND TOPOGRAPHY AND OTHER BASE MAPPING WAS PROVIDED BY BARR ENGINEERING, DATED 10/3/2006, VILLAGE HARBOR.
3. EXCAVTION SIDE SLOPE WILL BE 1 FOOT HORIZONTAL TO 1 FOOT VERTICAL OR FLATTER DEPENDING ON CONDITIONS ENCOUNTERED DURING EXCAVATION.
4. SEE FIGURE 4-3 FOR CROSS-SECTION D-D'.
5. AVERAGE LAKE ELEVATION OBTAINED FROM LUDINGTON AND MACKINAW CITY GAUGE STATIONS. (WWW.CO-OPS.NOS.NOAA.GOV)



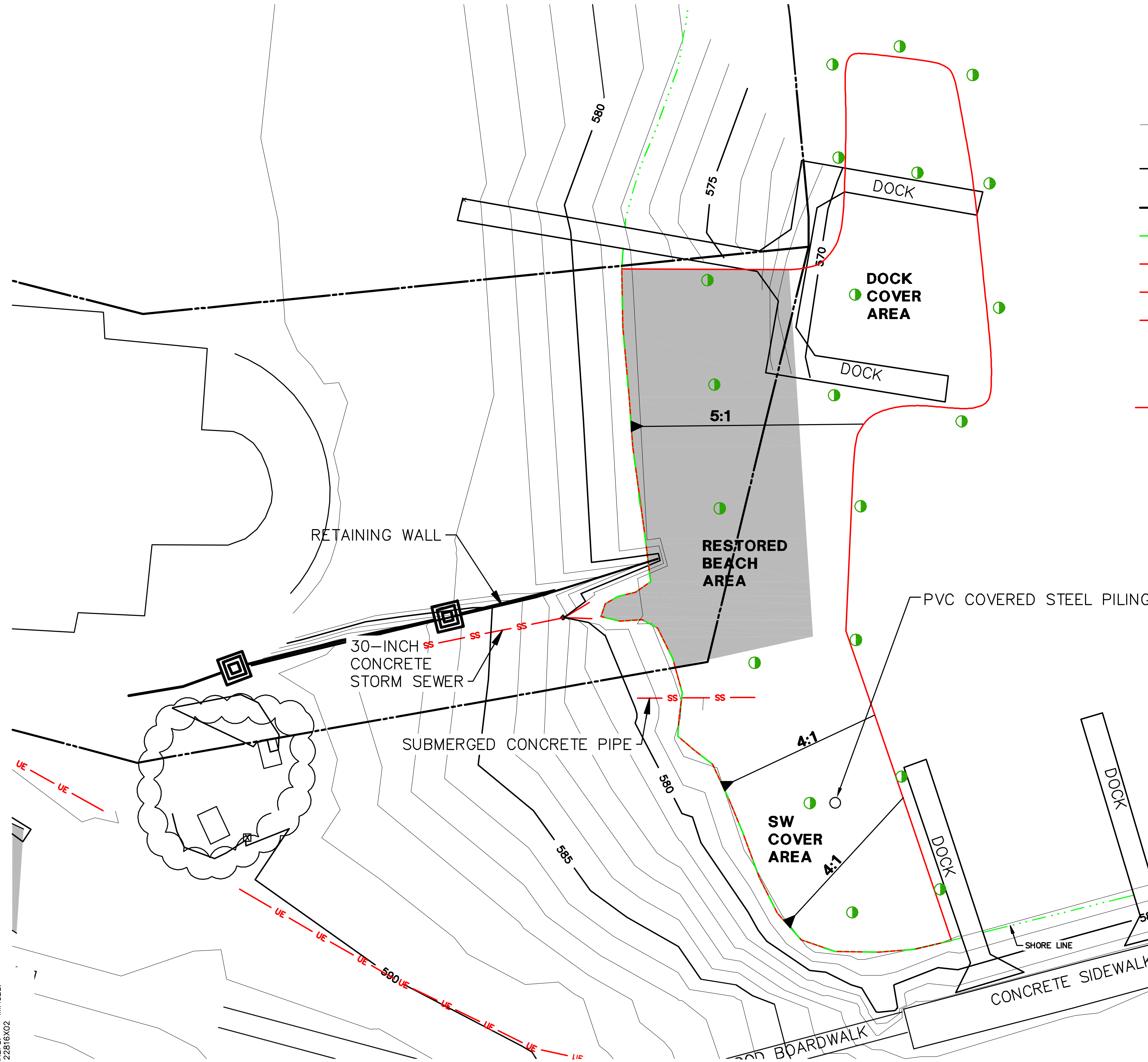
CMS LAND COMPANY
VILLAGE HARBOR, EMMET COUNTY, MICHIGAN
SW CORNER REMOVAL ACTION WORK PLAN

COVER CROSS-SECTION D-D'

ARCADIS
Infrastructure, environment, facilities

FIGURE
4-6

BRI-85-ADF LAYER: ON=*, OFF=*REF*
J:\2008\B0022816\0000\00100\DWG\22816V07.DWG SAVED:1/7/2008 10:59 AM LAYOUT:Layout1 PAGESETUP:---- PENTABLE:PLTFULL.CTB PRINTED:1/7/2008 10:59 AM BY:AFOX
PROJECTNAME:---- IMAGES: c-c[1].tif
XREFS:



LEGEND:

	EXISTING INTERMEDIATE LAND CONTOURS (1 FOOT INTERVAL)
580	EXISTING INDEX LAND CONTOURS (5 FOOT INTERVAL)
	PROPERTY LINE
	APPROXIMATE SHORELINE
UE UE	UNDERGROUND UTILITY
GAS GAS	GAS LINE
SS SS	STORM SEWER
	COVER MONITORING LOCATION
	BEACH RESTORATION AREA
	PERIMETER OF COVERED AREA

NOTES

1. UPLAND TOPOGRAPHY AND OTHER BASEMAPPING PROVIDED BY BARR ENGINEERING DATED 10/3/2006, VILLAGE HARBOR 2006.dwg
2. SITE CONTROL IS BASED OFF AERIAL SURVEY COMPLETED IN DECEMBER, 2004.
3. HORIZONTAL DATUM IS NAD83/94 MI. STATE PLANE CENTRAL ZONE.
4. VERTICAL DATUM IS NAVD88.
5. MONITORING WILL BE PERFORMED FOR pH SHALL BE CONDUCTED QUARTERLY FOR ONE YEAR POST-CONSTRUCTION. WATER SAMPLES TO BE COLLECTED FROM LOWEST 1-FOOT AND THE MIDDLE OF THE WATER COLUMN AT EACH LOCATION.

0 20' 40'
GRAPHIC SCALE

CMS LAND COMPANY
VILLAGE HARBOR, EMMET COUNTY, MICHIGAN
SW CORNER REMOVAL ACTION WORK PLAN

POST-CONSTRUCTION MONITORING LOCATIONS

ARCADIS
infrastructure, environment, facilities

FIGURE
4-7

ARCADIS BBL

Appendix A

Aerial Photographs

ARCADIS BBL

Appendix B

Supplemental Sediment Borings – Southwest Corner Area Report (BBL, December 2006)

ARCADIS BBL

Appendix C

Geotechnical Sample Results

ARCADIS BBL

Appendix D

Armor Design for Erosive Propeller Action

ARCADIS BBL

Appendix E

Excavation Slope Stability Analysis

ARCADIS BBL

Appendix F

Cover Slope Stability Analyses –
Short-Term Condition

ARCADIS BBL

Appendix G

Cover Slope Stability Analyses –
Long-Term Condition

Appendix A

Aerial Photographs

N

Meters
50 0 50

Feet
100 0 100 200

Figure 2-1

1938 Aerial Photograph
Village Harbor
Little Traverse Bay CKD
Release Site
Emmet County, MI

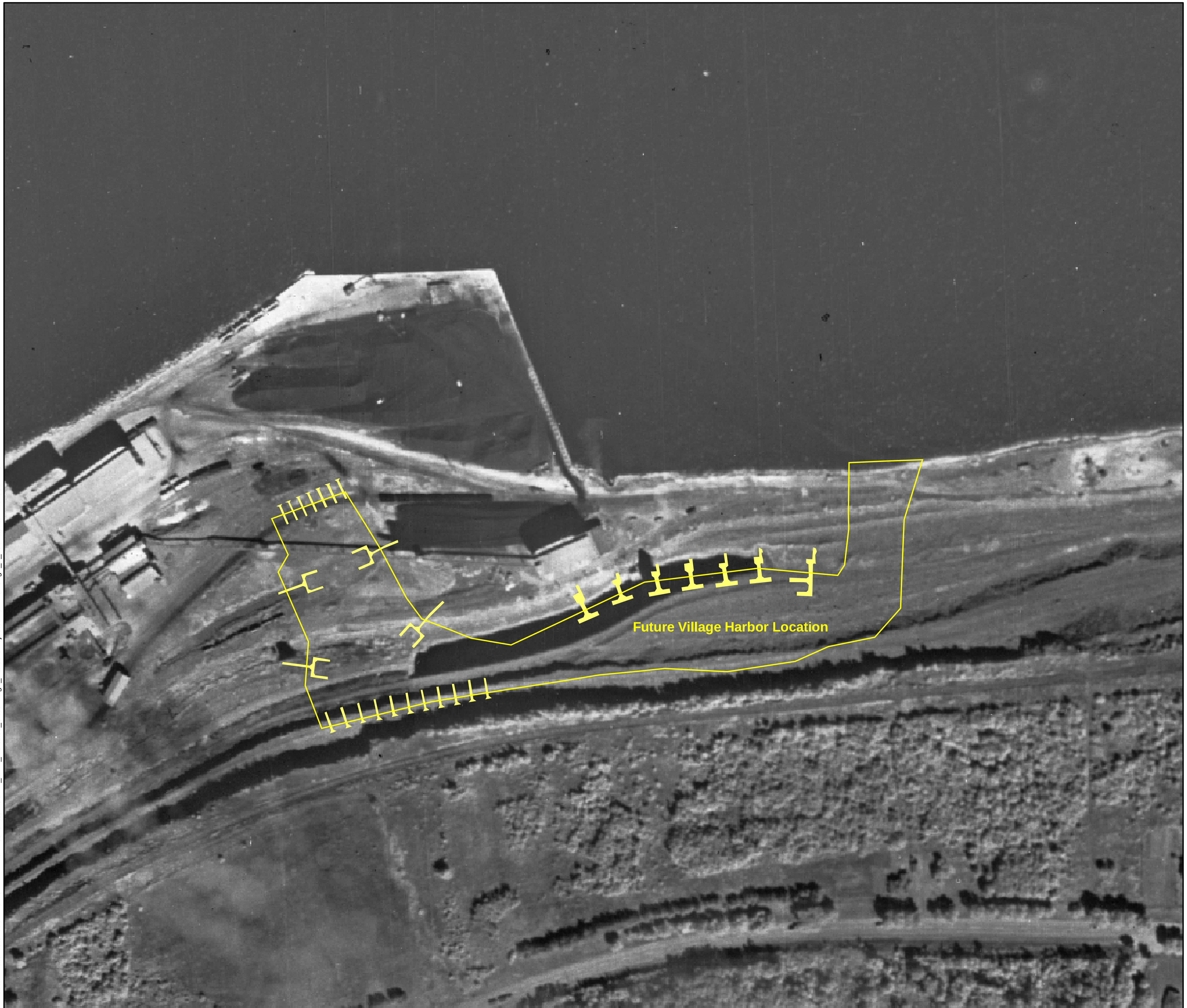
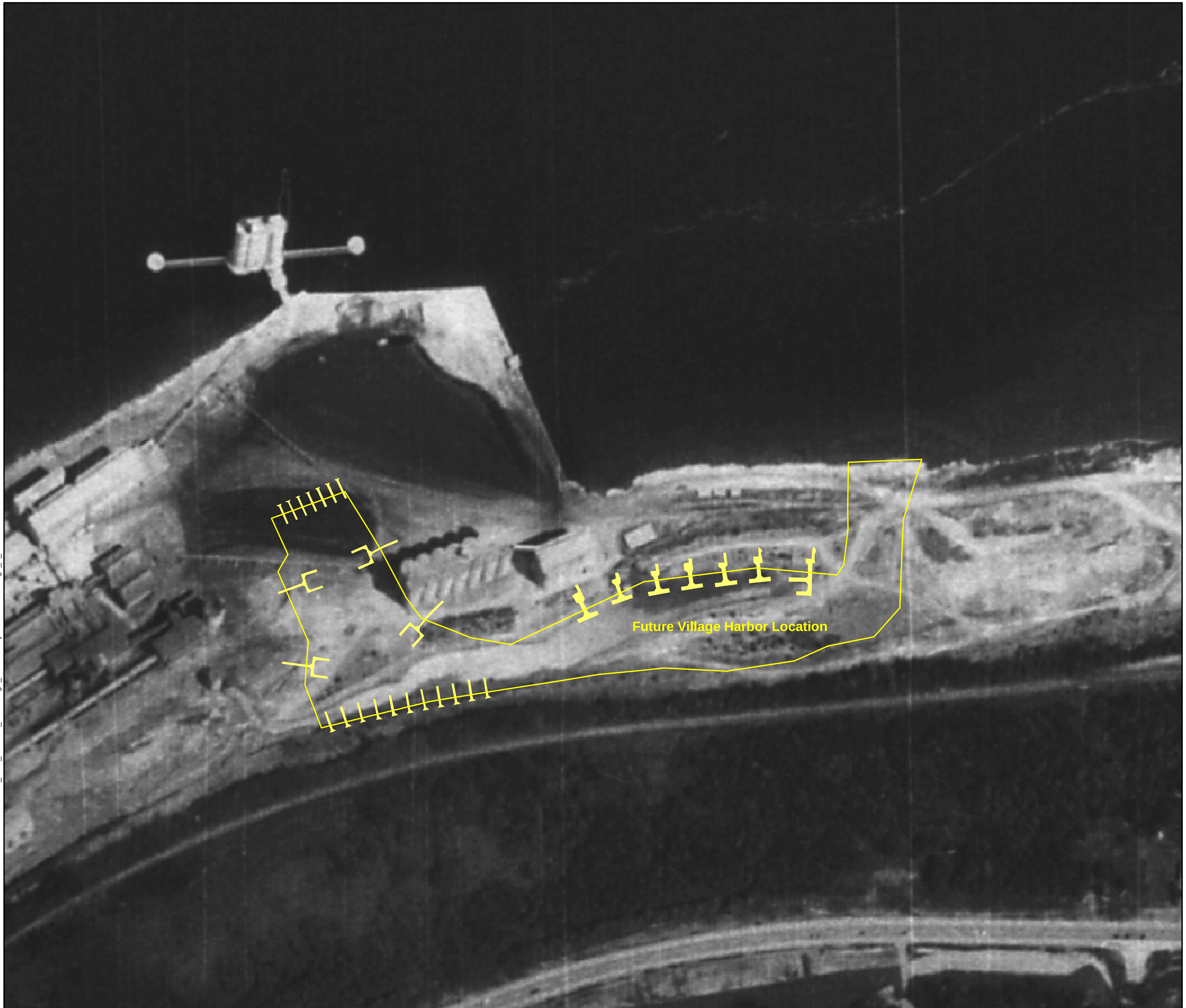


Figure 2-2

1952 Aerial Photograph
Village Harbor
Little Traverse Bay CKD
Release Site
Emmet County, MI



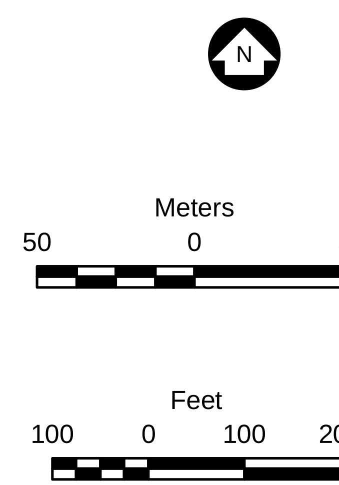


Figure 2-3

1973 Aerial Photograph
Village Harbor
Little Traverse Bay CKD
Release Site
Emmet County, MI

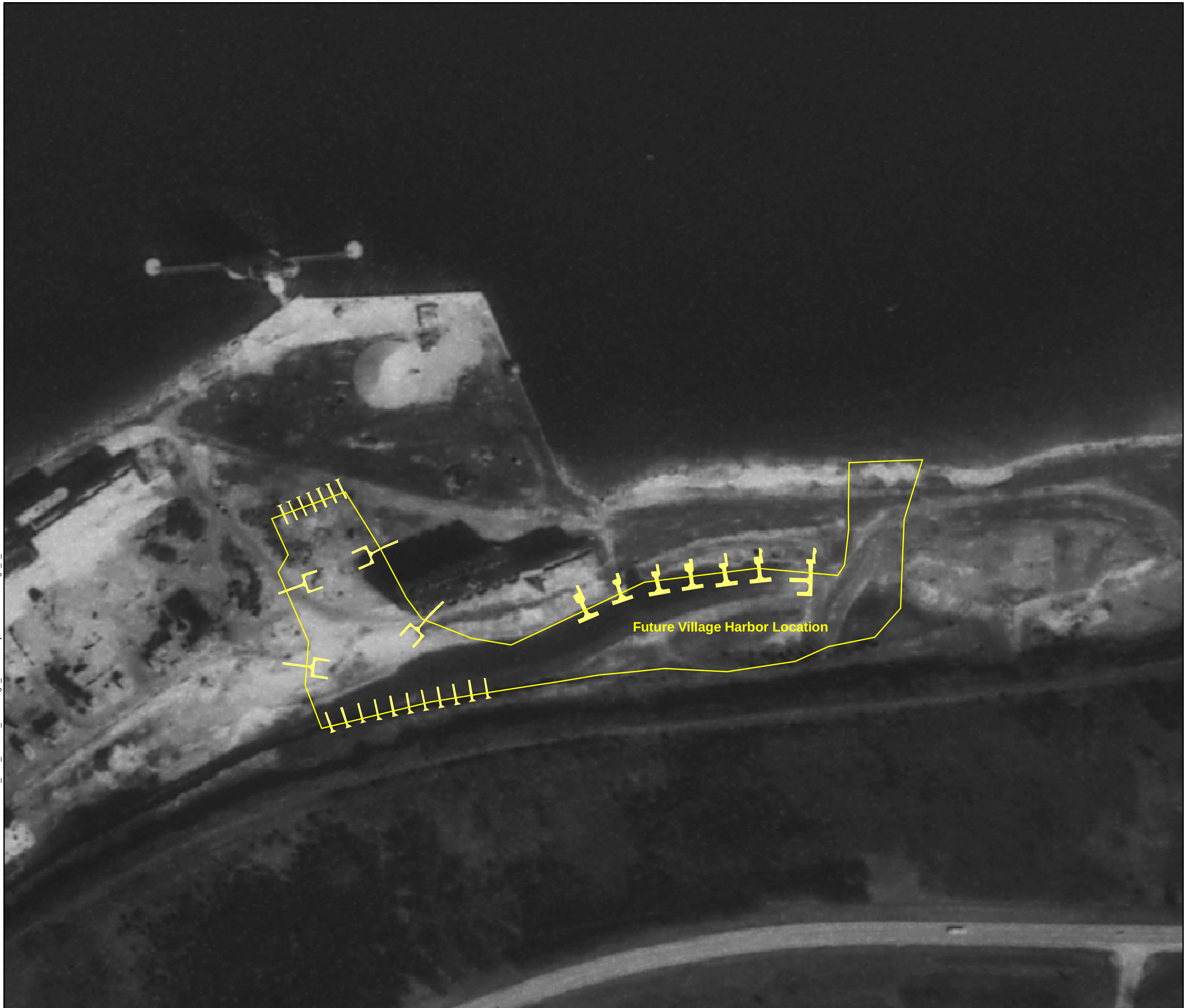
N

Meters
50 0 50

Feet
100 0 100 200

Figure 2-4

1974 Aerial Photograph
Village Harbor
Little Traverse Bay CKD
Release Site
Emmet County, MI



N

Meters
50 0 50

Feet
100 0 100 200

Figure 2-5

1993 Aerial Photograph
Village Harbor
Little Traverse Bay CKD
Release Site
Emmet County, MI

Appendix B

Supplemental Sediment Borings – Southwest Corner Area Report (BBL, December 2006)

Supplemental Sediment Borings Southwest Corner Area Remedial Investigation Village Harbor

CMS Land Company and CMS Capital, LLC

December 2006

BBL®
an ARCADIS company

REPORT

Supplemental Sediment Borings Southwest Corner Area Remedial Investigation Village Harbor

CMS Land Company and CMS Capital, LLC
Little Traverse Bay CKD Release Site
Emmet County, Michigan
U.S. EPA Docket No. VW-05-C-810

December 2006

Table of Contents

1. Introduction

1.1 Background

As presented in the *Village Harbor Proposed Removal Action Alternatives Report-Southwest Corner* Alternatives Analysis report (Barr, 2006a) sediment sampling was completed in Village Harbor using manually-pushed core samplers and surface sediment grab samples. The methods used were presented in the document entitled *Summary of Current Conditions/Work Plan for Village Harbor* (Remedial Investigation [RI] Workplan) (Barr, 2006b). Soft surface sediment samples were collected in the southwest corner area and the sump area (Figure 1), but the sampling effort was not successful in collecting deeper coarse or hardened materials. Only surface grab samples of soft surface sediments in the southwest corner area were recovered. No cores were advanced in the southwest corner area due to the presence of very coarse sediments below the soft surface layer.

Upon completion of the field sampling activities described in the RI Workplan (Barr 2006b), and as presented in the alternatives analysis (Barr 2006a) and field notes remaining data gaps in the southwest corner area included:

a) general physical properties and reactivity of sediments beneath soft surface sediments; and

b) thickness of reactive materials beneath soft surface sediments.

To supplement the RI results obtained previously, supplemental sediment borings were completed in both the southwest corner area and the sump area of Village Harbor on November 2 and 3, 2006. This supplemental RI report describes the activities and results associated with the southwest corner area. The sump area activities and results are presented in a separate report.

1.2 Supplemental Sampling Objectives

The objectives of the southwest corner area supplemental sampling were to determine the physical characteristics, thickness, and reactivity of the coarse-grained or hardened reactive materials present in the southwest corner area.

As previously discussed, this supplemental RI report describes the activities and results associated with the southwest corner area. The sump area activities and results are presented in a separate report.

1.3 Supplemental Boring Program Overview

Three sediment borings were completed in the southwest corner area by STS Consultants, Ltd. (STS), under contract to BBL, on November 2 and 3, 2006 at the locations shown on Figure 2. The sediment borings completed as part of this supplemental RI were completed using a barge-mounted drilling rig. The barge-mounted drilling rig was used to obtain samples from the relatively hard or coarse sediments and to define the full sediment thickness of these materials (to refusal) in the southwest corner area.

2. Supplemental Investigation

2.1 Sampling Program

2.1.1 Sampling Methods

The sediment borings were completed with a barge-mounted drilling rig which was trailered to the site from Green Bay, Wisconsin. The barge and rig, which measured 11 feet wide by 22 feet long, were placed in the harbor at the southwest corner using a crane operated by Petoskey Crane Rental (contracted by STS). Photos of the crane, drilling rig and barge, and the supplemental RI field work activities are included in Appendix A. In the water, the barge was moved between boring locations by a separate 16-foot flat bottom boat with an outboard motor that was attached to the barge while motoring. The boat could also be detached from the barge to transport crew to shore. During drilling, the barge was anchored by driving metal posts attached to the corners of the barge (i.e. anchor spuds) into the underlying sediment.

Prior to beginning drilling activities each day, a safety meeting was held to review potential hazards and safe operating practices. The daily safety meetings were documented on Barr's Form 4 which was submitted to Mr. Jeremy Hutson of Barr at the end of each work day. In addition, the barge, rig, and boat were checked to ensure proper working condition and that all emergency response equipment was on board and working properly. The Boat Safety Checklist (Barr's Form M-1) was completed at the beginning of both days of drilling. Prior to beginning any field activities, on November 1, 2006, on-site staff from BBL, STS and the crane operators (Petoskey Crane Rental) reviewed the site-specific health and safety procedures with Mr. Hutson at the East Park job trailer. Documentation of the site-specific training is maintained at the Barr job trailer.

The borings were advanced using rotary drilling technique with continuous sampling. A 2-foot split-barrel sampler was first driven into the sediment to collect an undisturbed sample using a standard 140-pound hand-controlled hammer. Once the sampler had been driven 2 feet and extracted, the 2-foot sampling interval was reamed using the rotary bit (3 7/8-inch tri-cone bit). After the 2-foot interval was reamed to a diameter of approximately 4 inches, a 4-inch steel casing was driven down to seal off the boring and to prevent collapse. The steel casing was driven down using the sampler hammer. Once the boring was terminated, the steel casing was removed from the boring and, due to saturated conditions, the boring collapsed.

2.1.2 Sampling Locations

The boring locations were recorded using triangulation by measuring the distance between each boring and at least two identifiable locations. Typically the bearing of the corner pilings on the nearest docks were used to triangulate the location. Coordinates were based on these reference points and geo-referenced air photos of Village Harbor. Coordinate readings were taken in the field using a hand held global positioning system (GPS) meter (Garmin 76 GPS); however, due to the positioning accuracy of the hand-held unit (without a base station), the coordinates determined by triangulation from reference points are believed to be most accurate and are the reported coordinates (Table 1). As shown on Figure 2, borings BBL-01(06), BBL-05(06) and BBL-06(06) were completed in the southwest corner area.

2.1.3 Sample Classification and Reactivity Measurement

All sediment samples were visually classified using the Unified Soil Classification System (USCS) and field measurements of reactive material were conducted based on a modification of the field screening procedures for testing for potential presence of reactive material described in Barr's *Standard Operating Procedure for Field Screening Cement Kiln Dust Samples* (SOP). The SOP was modified slightly in that more distilled water was added to each sample to ensure that the subsequent pH reading was representative of the sediment conditions and not the residual water present within the sample. Approximately 4 ounces of distilled water was added to each sample instead of the 1 to 2 tablespoons specified in the SOP. Elevated pH (greater than 9 standard units [s.u.]) was presumed due to the presence of reactive material.

2.1.4 Boring Logs and Sample Photographs

Sediment borings logs were prepared based on the field notes. Boring logs and field notes are presented in Appendices B and C, respectively. In addition, photographs were taken of samples, which are included in Appendix D.

The elevation of the soil sample intervals shown in Table 1 was calculated based on the estimated average surface water elevation within the marina using Lake Michigan water surface elevation records from the National Oceanic and Atmospheric Administration (NOAA) Mackinaw City, Michigan gauging station. The data from this gage were used because the site gage in Bay Harbor was temporarily out of service. Based on comparison of water level readings by the site gage and the Mackinaw City gauging station, the Mackinaw City water levels closely match water levels at the site, so any error in the boring log elevations potentially resulting from use of the Mackinaw City gage is believed to be minor. The average water surface elevation in Village Harbor during November 2 and 3, 2006 when the borings were collected was estimated using the value from the approximate midpoint of the working hours during which the borings were completed (2:00 p.m. on November 2, 2006 and 9:30 a.m. on November 3, 2006). The elevation datum for the NOAA data is the 1985 International Great Lakes Datum (IGLD). All sediment boring sample depths and intervals described in this report are based on the IGLD.

3. Sampling Results

The sediment materials encountered in the borings conducted in the southwest corner area are described in the following sections. Sediment pH readings taken on materials from the boreholes are shown in Table 1.

3.1 Sample Classification and Reactivity Measurement Results

The borings completed in the southwest corner (BBL-01(06), BBL-05(06), and BBL-06(06)) encountered primarily coarse gravel to cobble-size pieces of crushed limestone with a grayish silty/clayey material intermixed. Based on sediment pH readings reported in Table 1, and the appearance of the material encountered, these borings appear to contain intervals with reactive materials. A whitish very fine material is evident on the sediment surface throughout the southwest corner of the harbor. This material was too fine to be recovered in the split-spoon sampler. Soft surface sediment thickness probing results conducted by Barr at locations HMD-45 through VHMD-53 (Barr 2006a) indicated a soft surface sediment layer of 0.4 to 2.2 feet thick in the vicinity of borings BBL-01(06), BBL-05(06) and BBL-06(06). Based on observations from the probing data collected by Barr, and observations of the boring program, the soft surface sediment thickness is highly variable in this area – probably associated with variable surface of the coarser materials underneath (placed rip rap, crushed rock remaining from construction of the harbor, etc.). As shown in Table 1, sediment pH values within the southwest corner area range from 9.5 to 11.6 s.u. with a mean value of 10.6 s.u. The sediment pH values generally increase with depth.

<u>Boring BBL-01(06)</u>

Boring BBL-01(06) was advanced to a depth of 18.5 feet below water surface (bws) (12.5 feet below sediment surface [bss]). The samples recovered from the split-spoon sampler showed primarily cobble-size limestone pieces with some grayish fine-grained sediment intermixed. When tested, the samples recovered from the 0 to 2, 4 to 6 and 10 to 12-foot bss intervals showed pH values of 9.5, 9.9 and 10.9 s.u., respectively. Boring BBL-1(06) was terminated at the depth of approximately 12 feet bss. Refusal was not encountered at that depth.

<u>Boring BBL-5(06)</u>

As with boring BBL-1(06), cobble-size limestone pieces intermixed with fine-grained sediment were encountered in boring BBL-5(06) in the 0 to 2-foot depth interval. In the 2 to 4-foot interval sample, some limestone cobbles were present overlying a dense gray to greenish-gray fine-grained material that produced a pH value of 10.6 s.u. The boring was terminated at approximately 4 feet bss due to very rough drilling and inability to advance the split-spoon sampler (assumed to be bedrock surface, a limestone boulder, or other obstruction).

Boring BBL-6(06)

Similar to borings BBL-1(06) and BBL-5(06), cobble-size limestone pieces intermixed with fine-grained sediment was encountered in boring BBL-6(06) in the 0 to 2-foot bss depth interval. In the 2 to 4 and 4 to 6-foot bss intervals, a dark greenish-gray to white material was observed that produced pH values of 10.8 and 11.0 s.u., respectively. Beneath this material, gray sand and gravel intermixed with some fine-grained material was encountered that produced a pH value of 11.6 s.u. Boring BBL-6(06) was terminated at a depth of approximately 7 feet bss due to very rough drilling and inability to advance the split-spoon sampler (assumed to be bedrock surface or a limestone boulder).

4. Discussion

All of the borings in the southwest area were advanced to refusal with a range of penetration bss of 4 to 12 feet. Borings BBL-01(06) and BBL-06(06) are located approximately 20 feet apart in the area targeted for excavation in the Alternatives Analysis (Barr 2006a) and were 12 and 8 feet bss respectively. Boring BBL-05(06) was located approximately 70 feet to the north of boring BBL-06(06) within the “U” shape of the existing dock (Figure 2). This boring encountered refusal at a depth of 4 feet bss.

Historical topographic information identified on a Penn-Dixie, Inc. Phase I existing and proposed grade drawing (Site Planning Development, Inc., 1980) suggests that the bedrock depression occupied by the sump area extended to the west to the southwest corner of Village Harbor. The bedrock depression was characterized by elevations below 550 feet IGLD. Borings BBL-01(06) and BBL-06(06) are located within this depression, as are Barr borings ST-01, ST-02 and ST-03, which are located on land just west of the BBL borings (as documented in the Alternatives Analysis [Barr, 2006a]). While BBL-01(06) was not terminated as a result of refusal, the refusal elevation in BBL-06(06) (562 feet IGLD) indicates that refusal was not on bedrock, but another obstruction (boulder, etc.). Based on an examination of the historical topography, refusal at boring BBL-05(06), which is located outside of the bedrock depression, is likely on bedrock. The bottom elevation of this boring (approximately 565.5 feet IGLD) is consistent with historical topographic information.

As discussed in Section 3.1, boring BBL-01(06) samples showed cobble-size limestone pieces intermixed with reactive material. A distinct reactive material layer was not identified. Both borings BBL-5(06) and BBL-6(06) samples also showed cobble-size limestone pieces intermixed with reactive material to approximately 2 feet bss although below this layer, at approximately 2 feet bss a more distinct reactive material layer was identified. The 2 to 4-foot interval sample from BBL-05(06) also contained some sand and gravel intermixed with the reactive material. In boring BBL-6(06) gray sand and gravel intermixed with reactive material was encountered at approximately 6 feet bss. Although a soft surface sediment layer may be present in the southwest corner area, this layer was not recovered in the split-spoon samples from any of the three borings.

pH values of the recoverable sediment from the 0 to 2 feet sample at borings BBL-01(06), BBL-05(06), and BBL-06(06) were 9.5, 9.9, and 10.2 s.u., respectively. The pH values in each of the borings from the southwest corner area increase with depth below each of these samples, suggesting higher content of reactive material with depth in the sediments surface.

The limestone cobble mixture identified in the borings may be a mixture of materials from historical disposal, material handling practices, demolition, and regrading during the construction of Village Harbor. Other source of the limestone cobbles may be rip rap placed for shoreline protection. Construction photographs circa 1995 show this area of the harbor being graded by bulldozers.

5. References

Barr 2006a. *Village Harbor Proposed Removal Action Alternatives Analysis Report Southwest Corner.* Little Traverse Bay CKD Release Site, Emmett County, Michigan. Prepared for CMS Land Company and CMS Capital, LLC. U.S. EPA Docket No. VW-05-C-810. November 7, 2006.

Barr 2006b. *Summary of Current Conditions/Work Plan for Village Harbor*, Little Traverse Bay CKD Release Site, Emmett County, Michigan. Prepared for CMS Land Company and CMS Capital, LLC. U.S. EPA Docket No. VW-05-C-810.

Site Planning Development, Inc. 1980. Penn-Dixie Industries, Inc., Cement Division, Petoskey, Michigan Plan, Phase I existing and proposed grades, November 7, 1980.

Tables

TABLE 1
SEDIMENT BORING SUMMARY
CMS LAND - BAY HARBOR
VILLAGE HARBOR SOUTHWEST CORNER AREA SUPPLEMENTAL RI BORINGS

General Location	Boring	Water Depth (feet)	Northing[3]	Easting[3]	Sediment Sample Depth Interval (feet below sediment surface)	Sediment Sample Depth Interval (feet below water surface)	Sediment Sample Interval Elevation[4] (feet IGLD)	Sediment pH[2] (Standard Units)	General Sediment Description (see boring logs in Appendix D for more detail)
Southwest Corner	BBL-1 (06)	6.3	19519220	748660	0 - 2	6.5 - 8.5	570.7 - 568.7	9.5	Limestone cobbles/gravel with gray fine-grained material intermixed.
					2 - 4	8.5 - 10.5	568.7 - 566.7	ND[1]	
					4 - 6	10.5 - 12.5	566.7 - 564.7	9.9	
					6 - 8	12.5 - 14.5	564.7 - 562.7	ND[1]	
					8 - 10	14.5 - 16.5	562.7 - 560.7	ND[1]	
					10 - 12	16.5 - 18.5	560.7 - 558.7	10.9	
	BBL-5 (06)	8.9	19519240	748750	0 - 2	9 - 11	568.2 - 566.2	9.9	Limestone cobbles/gravel with some fine-grained material intermixed.
					2 - 4	11 - 13	566.2 - 564.2	10.6	Limestone cobbles/gravel overlying clay-rich dense layer (till?); some white CKD-like reactive material present (based on pH value)
	BBL-6 (06)	8.5	19519220	748680	0 - 2	8.5 - 10.5	568.7 - 566.7	10.2	Limestone cobbles/gravel with some fine-grained material intermixed.
					2 - 4	10.5 - 12.5	566.7 - 564.7	10.8	CKD-like reactive material (based on pH value)
					4 - 6	12.5 - 14.5	564.7 - 562.7	11.0	
					6 - 8	14.5 - 16.5	562.7 - 560.7	11.6	Gray sand/gravel with some clay/silt intermixed

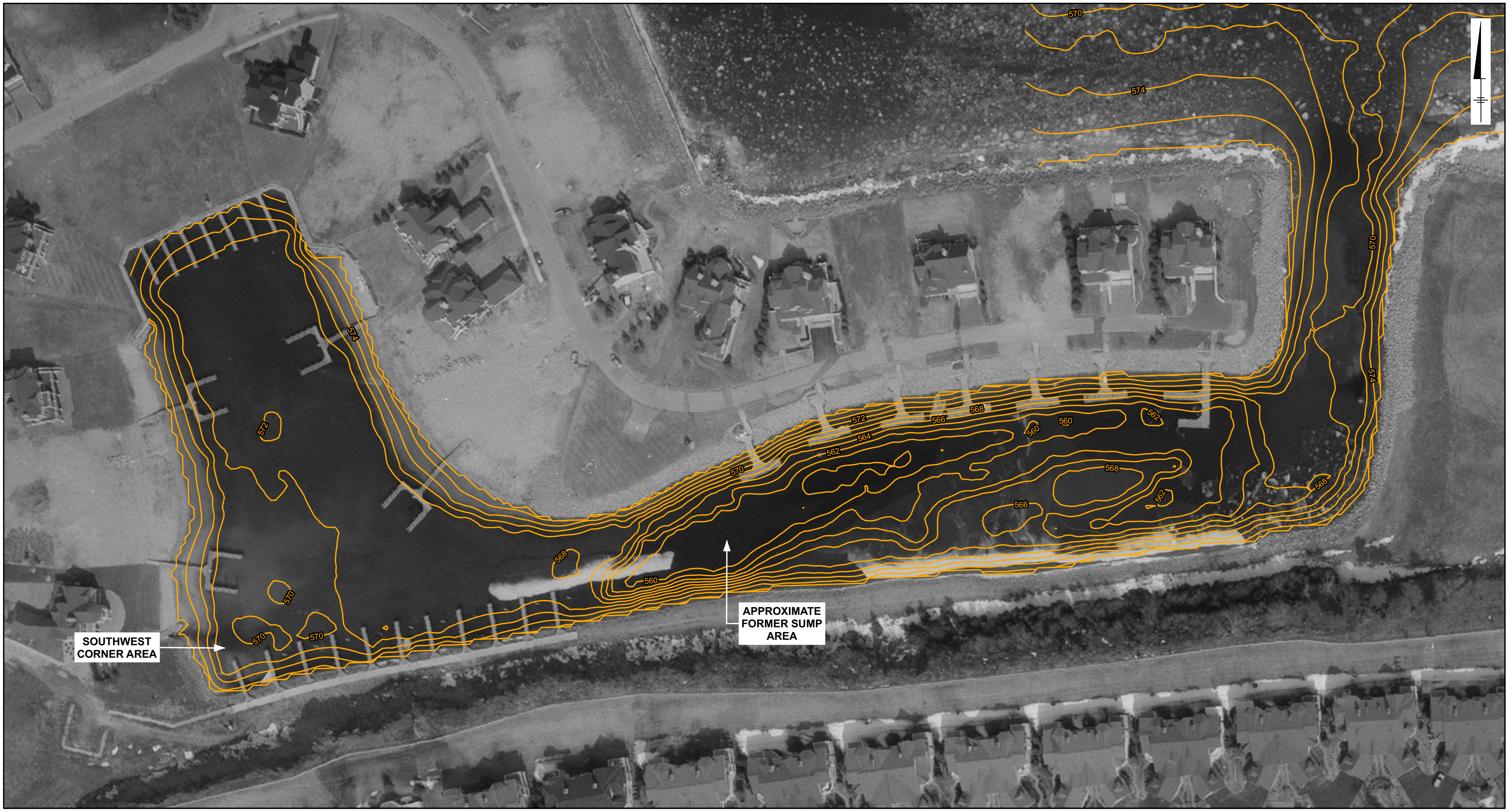
(1) ND = not done - not enough sample recovered to complete pH test

(2) Sediment pH was evaluated by mixing a portion of the Sediment sample with distilled water and testing the pH of the resulting leachate.

(3) Northing and easting locations based on State Plane, Michigan Central zone, North American Datum (NAD) 1983, International Feet. The boring locations on Figure 2 were located based on measurements from dock pilings. The boring location coordinates were then back calculated. The northing and easting values were rounded to the nearest 10 feet based on an estimated relatively accuracy of the field measurements.

(4) Elevations are in 1985 International Great Lakes Datum (IGLD) based on an average Lake Michigan elevation of 577.2 feet for November 2 and 3, 2006 taken from the National Oceanic and Atmospheric Administration (NOAA) Mackinaw City, MI gauging station.

Figures



LEGEND:

BATHYMETRY ELEVATION CONTOUR - 2 ft

0 100 200 Feet

GRAPHIC SCALE

NOTES:

1. AERIAL PHOTO COLLECTED IN APRIL 2005 PROVIDED IN GEOREFERENCED FORM BY BARR ENGINEERING, INC.
2. BATHYMETRY DATA ENTITLED 10ftSumpEleC.shp FROM BARR ENGINEERING, INC.

CMS ENERGY
VILLAGE HARBOR
LITTLE TRAVERSE BAY CKD RELEASE SITE
VILLAGE HARBOR SUPPLEMENTAL RI BORINGS

VILLAGE HARBOR SUPPLEMENTAL RI LOCATIONS

BBL an ARCADIS company

FIGURE
1

11/29/06 SYR-85 MTK
CMS Energy (22816.001) [SYR-85 MTK]
G:\ConsumersEnergy\VillageHarbor\SupplementalRI\mxd\Supplemental RI Locations.mxd

LEGEND:

- SEDIMENT BORING LOCATION - NOVEMBER 2006 (BBL)
- SEDIMENT SAMPLE LOCATION - SEPTEMBER 2006 (BARR ENGINEERING)
- BATHYMETRY ELEVATION CONTOUR - 2 ft

0 100 200 Feet

GRAPHIC SCALE

NOTES:

1. AERIAL PHOTO COLLECTED IN APRIL 2005 PROVIDED IN GEOREFERENCED FORM BY BARR ENGINEERING, INC.
2. BATHYMETRY DATA ENTITLED 10ftSumpEleC.shp FROM BARR ENGINEERING, INC.

CMS ENERGY
VILLAGE HARBOR
LITTLE TRAVERSE BAY CKD RELEASE SITE
VILLAGE HARBOR SUPPLEMENTAL RI BORINGS

VILLAGE HARBOR SEDIMENT SAMPLE LOCATIONS

BBL an ARCADIS company

FIGURE
2

11/29/06 SYR-85 MTK
CMS Energy (22816.001) [SYR-85 MTK]
Q:\ConsumersEnergy\VillageHarbor\SupplementalRI\mxd\Sediment Sample Locations.mxd

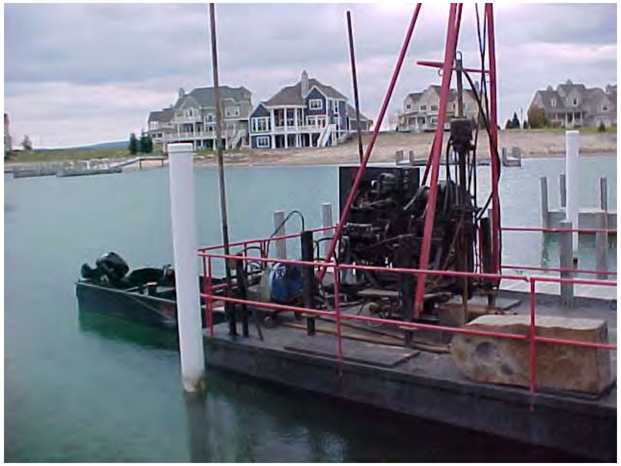
Appendix A

Field Work Photographs

November 1, 2006

Barge and rig installed into dock slip
(view from southwest)

Barge and rig installed into dock slip
(view from southeast)



View of john boat attached to rear of barge

November 2, 2006

View of rig head

Moving barge into position

Open split-spoon sampler with sample

Attaching smaller diameter rod to advance split-spoon sampler

November 2, 2006

Attaching section of outer casing prior to advancement

Attaching section of outer casing prior to advancement

November 3, 2006

Boring BBL-06(06)

Attaching crane lines to barge

Removing barge from water

Lowering barge onto trailer

November 3, 2006

Barge lowered and secured to trailer

Barge leaving site

Crane leaving site

Appendix B

Sediment Boring Logs

BBL®
an ARCADIS company

Date Start/Finish: 11/2/06 **Drilling Company:** Subsurface Testing Services **Driller's Name:** Randy Treml **Drilling Method:** Rotary/Split Spoon **Bit Size:** 3 7/8" **Auger Size:** NA **Rig Type:** Joy Skid Rig/Barge **Sampling Method:** 2" OD	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 18.5' bws **Surface Elevation:** 577.2 **Geologist:** Matt Stuk	**Well/Boring ID:** BBL-1 (06) **Client:** CMS Land **Location:** Bay Harbor, MI

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	pH	USCS Code	Geologic Column	Stratigraphic Description	Hydrostratigraphy	Well/Boring Construction
	580											
0										Water.		
	575											
5												
	570	1	2" SS	1.2	NA NA NA NA	NA	9.5	NA		Limestone chunks with gray fine-grained material intermixed.	GRAVEL	
10		2	2" SS	0.3	5 7 14 12	21	NA	NA				Natural Collapse.
	565	3	2" SS	0.25	14 35 14 24	49	9.9	NA				
		4	2" SS	0.3	6 8 10 11	18	NA	NA				
15		5	2" SS	0.42	5 11 31 30	42	NA	NA				
	560	6	2" SS	0.3	20 12 8 11	20	10.9	NA				

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Remarks: bws - below water surface

SAA - same as above

NA - not available/not applicable

CKD - cement kiln dust

Elevation datum is International Great Lakes Datum 1985.

Date Start/Finish: 11/3/06 **Drilling Company:** Subsurface Testing Services **Driller's Name:** Randy Treml **Drilling Method:** Rotary/Split Spoon **Bit Size:** 3 7/8" **Auger Size:** NA **Rig Type:** Joy Skid Rig/Barge **Sampling Method:** 2" OD	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 13' bws **Surface Elevation:** 577.2 **Geologist:** Matt Stuk	**Well/Boring ID:** BBL-5 (06) **Client:** CMS Land **Location:** Bay Harbor, MI

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	pH	USCS Code	Geologic Column	Stratigraphic Description	Hydrostratigraphy	Well/Boring Construction
	580											
0										Water.		
	575											
5												
	570											
10		1	2" SS	0.67	25 38 50 NA	88	9.9	NA		Limestone chunks with some fine grained material within the matrix.	FILL	Natural Collapse.
	565	2	2" SS	0.75	35 50 NA NA	50	10.6	NA		Dense Clay-rich Till (?), gray to greenish gray, some Sand and Gravel, some whitish CKD-like reactive material (based on pH value) present.		
										Refusal.		
15												

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Remarks: bws - below water surface
SAA - same as above
NA - not available/not applicable
CKD - cement kiln dust
Elevation datum is International Great Lakes Datum 1985.

Date Start/Finish: 11/3/06
Drilling Company: Subsurface Testing Services
Driller's Name: Randy Treml
Drilling Method: Rotary/Split Spoon
Bit Size: 3 7/8"
Auger Size: NA
Rig Type: Joy Skid Rig/Barge
Sampling Method: 2" OD

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 16.5' bws
Surface Elevation: 577.2
Geologist: Matt Stuk

Well/Boring ID: BBL-6 (06)

Client: CMS Land

Location: Bay Harbor, MI

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	pH	USCS Code	Geologic Column	Stratigraphic Description	Hydrostratigraphy	Well/Boring Construction
	580											
0										Water.		
	575											
5												
	570											
10		1	2" SS	0.6	3 21 34 50	55	10.2	NA		Limestone chunks and some Clayey material within matrix.	FILL	Natural Collapse.
	565	2	2" SS	0.8	15 8 36 31	44	10.8	NA		Greenish gray to white soft to semi-lithified CKD-like reactive material (based on pH value).		
		3	2" SS	0.7	30 50 NA NA	50	11.0	NA				
15		4	2" SS	0.4	22 50	50	11.6	NA		Gray Sand and Gravel with some Clay and Silt intermixed.		
										Refusal.		

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Remarks: bws - below water surface
SAA - same as above
NA - not available/not applicable
CKD - cement kiln dust
Elevation datum is International Great Lakes Datum 1985.

Appendix C

Field Notes

Location Bay Harbor, MI Date 11/1/06

Project / Client CMS

5:00 - 9:45 Travel to site.

9:45 meet w/ Bill Zakowski, Jerry and ~~Matt~~ Bowman from STS. Tell them we need to wait for HASP approval but may be able to get site-specific training in mean time.

10:00 Call Jeremy Hutson from Barr to set up site-specific training at East Pile job trailer.

10:45 Arrive @ job trailer w/ STS and Frank ~~Ist~~ ~~&~~ Jim from Petoskey Crane Rental to get site-specific training from Jeremy.

11:15 Finish training - break to get e-mail and check on HASP approval

Location Bay Harbor, MI Date 11/1/06

Project / Client CMS

14:40 Talk to Chris Peters - Ellen R. will give partial approval on barge deployment to get barge and boat in water. May have full HASP approval tonight to begin drilling tomorrow

15:00 - 16:00 - deploy barge and boat into first slip nearest southwest corner of Marina

Jeremy Hutson from Barr drops by to see progress.

16:20 STS is securing barge and boat in dock slip to cleats.

Off-site @ 1647

1658 drop off Form 4 and SSA w/ Jeremy

Location Bay Harbor, MI Date 11-2-06

Project / Client CMS

Weather mid-30s, wind: 10-15 W, snow

STS - Matt Bowman, Randy Treml, Bill Zakowski
BBL - Matt Stuk

- 1015 Talk to Chris Peters - we have approval on HASP from Ellen Richard - OK to proceed.

1030 On site prep to move to first location between dock and land within fence (location of 12 pH reading). Safety tailgate meeting.

1115 Boring BBL-1 (06).
located directly between end of dock and shore. 6.3' of water (~8' from top of barge).

[GPS location 0655684/5025811]

Depth	Recovery	Description
0-2'	14"	Limestone chunks gray. with some fine-grain material w/in matrix.
2-4'	4"	"

Bay Harbor, MI 11-2-06
CMS.

Depth	Recovery	Description
4-6'	3"	Limestone chunks, gray.
[water pH reading = 9.0 s.u.]		
6-8'	4"	"
8-10'	5"	"

Decide to end boring - appears to be all gravel. Will move to do borings in main part of sump and come back to southwest corner tomorrow.

Boring BBL-2 (06)

located near former borings 14/17, Water Depth from barge = 19.5'

Boring from southwest piling on nearest north-side dock = 69'
Boring from southeast piling on nearest north-side dock = 105'
GPS = 0655840 / 5025839

Location Bay Harbor Date 11-2-06

Project / Client CMS

BBL-2(06) (cont.)

- first sample - split spoon sunk to approx. 22' recovered 6" of material. bluish harder material on top of whitish-gray very soft material (CKD?). Collected sample and took picture.

from barge deck

Depth	Rec.	Description
~~0-3.5'~~ 19.5-23'	6"	above

23-25' → spoon sunk to 25' no sample recovered.

25-27' 10" Bluish soft to lithified sediment - very fine grained
→ very hard pounding for 10 blows and then "broke through" to 27'.

27-29' 1" of bluish material overlying 6" of brown fine grained material. Last (deepest) 3" is very dark brown harder material

Bay Harbor 11-2-06

CMS

BBL-2(06) (cont.)

- at 29' split-spoon "burned" indicating bedrock surface. Attempted to drill through using tri-cone bit. Drilled for 10 minutes with negligible advancement. Attempted split-spoon sample.

No advancement of spoon at 29'. Retrieved spoon w/ 6" of slough from above (boring had caved slightly) and shards of limestone in tip.

End of boring ~~BBL~~-2.

MS

Location Bay Harbor Date 11-2-06

Project / Client CMS

1440 Set up on Boring $\boxed{\text{BBL-3 (06)}}$ near former boring 15.

Location: from southeast ~~to~~ piling on 2nd dock = 63'
from southwest piling on 2nd dock = 39'

GPS = 655879/5025862

21.8' water depth from barge deck.

$\boxed{\text{BBL-3 (06)}}$

Depth	Rec.	Desc.
22-24	6"	brown finer material with some sand + gravel - may be native.
24-26	12"	Light gray fine-grained material (CKD), hard pounding near 26!

Bay Harbor 11-2-06
CMS

$\boxed{\text{BBL-3 (06) (cont.)}}$

26-28' 4" of clayey sand + gravel, gray, overlying 9" of brown very fine (silty) material (CKD?) - 13" total recovery.

28-30' 14" total recovery. upper 11" same fine brown material as last spoon. Bottom 3" clayey sand + gravel (limestone shards) - bottom 3" may be native material.

30-32' limestone chunks - pounding on limestone @ 31.7'

End of boring @ 31.7'!

Location Bay Harbor Date 11-2-06

Project / Client CMS

- move to location BBL-4 (06) between 2nd & 3rd dock on north side.

Location from SE piling on ~~3rd~~ 2nd dock: 33'

" " SW piling on 3rd dock: 27'

- GPS: 655892 / 5025872

- Water depth = 21.0 feet from barge dock

BBL-4 (06)

	Rec.	
21-23'	3"	Limestone chunks.

rough drilling from ~~23~~ 21 as 23 feet may be directly on limestone surface.

23-25'	8"	brown Clayey / Silty material w/ few sand, trace greenish material (CKG)

Bay Harbor 11-2-06

CMS

BBL-4 (06) (cont.)

Depth	Rec.	
25-27	4"	small amount of brown material (same as last spoon) with limestone chunks. Large chunk in tip

Continued drilling very rough from 27-28 then hitting limestone.

end of boring @ 28'

1745 off-site

MB

Location Bay Harber Date 11/2/06

Project, Client CMS

pH readings of soil samples collected on 11/2/06.

2045 pH meter calibrated to 7 and 10 solutions.

Distilled water used to mix with soil samples. pH of distilled water = 6.96

Samples also evaluated according to the SOP for Field Screening Cement Kiln Dust.

BBL-2 (20-22')
10YR 4/2, soft, ~~weak,~~ reacts w/ HCl
ms
pH = 10.4

BBL-2 (27-29')
5Y 4/2, soft, ~~weak,~~ reacts w/ HCl
ms
pH = 9.0

Bay Harber 11/2/06
cms

BBL-2 (25-27')
GLEY I 7/5G, non-plastic, hard, reacts w/ HCl, firm to hard, pH = 10.7

BBL-3 (24-26')
GLEY I 7/5G, non-plastic, hard, reacts w/ HCl, pH = 10.4

BBL-3 (26-28')
5Y 4/1, soft, reacts w/ HCl,
pH = 8.5

NOTE: the pH meter was checked between each reading in distilled water. The meter read ~~7.2~~ 7.1 ms or lower during each check. If not, it was recalibrated.

BBL-3 (22-24')
5Y 4/1, soft, reacts w/ HCl,
pH = 8.5

Location Bay Harbor Date 11/2/06

Project / Client CMS

ms BBL-4 (23-25')

5Y 6/2 ~~5Y 4/2~~, soft, reacts w/ HCl
pH = 8.1

BBL-3 (28-30')
5Y 3/2, soft, reacts w/ HCl
pH = 8.3

BBL-4 (25-27')
5Y 4/2, soft, reacts w/ HCl
pH = ~~7.3~~ ms redo 7.9

1205 pH meter recalibrated

MS

Location Bay Harbor Date 11-3-06

Project / Client CMS

750 - Onsite with:
STS - Bill Zakowski, Randy Treml
Matt Bowman
BBL - Matt Stek

Safety Meeting - cold, wind, slippery deck, overhead equipment, check barge - all PPE on board.

began borings in southwest corner.

Weather: mid-30s, wind: 5-10 W, light snow

MS

Location Bay Harbor 11-3-06

Project / Client CMS

- set up on boring BBL-05 (06) located within "U" dock just north of southwest conr (south side of the "U").

- Water depth = 8.9' from barge dock.

- Location = directly adjacent to south dock of "U" 15 feet northwest of southeast piling and 25 feet northeast of southwest piling.

GPS = 655693/5025830

BBL-5 (06)

Depth	Rec.	Description
9-11	8"	Limestone chunks w/ some f-grain sediment within the matrix. will do pH and fizz test on sediment later.

Location Bay Harbor Date 11-3-06

Project / Client CMS

BBL-5 (06) (cont.)

Depth	Rec.	Description
11-13	9"	Some limestone chunks overlying a dense clay-rich fill (?), gray to greenish-gray, some sand + gravel. some whitish material present (CKD or marl?).

very difficult drilling at 13'. - assume at bedrock surface. Attempted split spoon sample but could not penetrate. Assume to be on limestone. End of boring at 13 feet.

950 move to boring between first south dock and U-dock. Directly between north~~east~~ west piling on first dock and southwest piling on U dock (22' feet from first dock piling). This will be BBL-6 (06).

Location Bay Harbor Date 11-3-06

Project / Client CMS

Boring $\boxed{\text{BBL-6 (06)}}$

- Location on previous page. No GPS location - GPS unit readout is wandering.

Water depth = 8.5' from barge deck.

Depth	Rec.	Desc.
8.5 - 10.5	7"	Limestone chunks and some clayey sediment w/in matrix
10.5 - 12.5'	10"	greenish gray to white soft to semi-lithified material
12.5 - 14.5	8"	similar to last spoon
14.5 - 15.4	5"	gray sand + gravel w/ some clay + silt - refusal at 15.4'

Bay Harbor 11-3-06

CMS

- very difficult drilling at 15.4' and could not advance spoon. Assume on bedrock or limestone boulder. Abandon boring. End of boring at 15.4 feet.

1125 Crane on site to remove barge and boat.

1305 Barge and boat removed. ~~Crane off site.~~ ms

1315 STS and BBL off site. Stop by East Pile trailer to drop off Form 4 and face shield with Jeremy Hutson. Crane off site

- Randy Tweel noted old drain just west of BBL-6 - took picture.

Location Bay Harbor Date 11-6-06

Project / Client CMS

pH test of samples collected on 11/3/06

920 - pH meter calibrated to 7 and 10 buffers. pH reading of distilled water = 6.59

BBL-5 (9-11')
ms ~~10YR 4/1,~~ reacts w/ HCl, pH = 9.9
5Y 5/1

BBL-5 (11-13')
5Y 4/1, reacts w/ HCl, pH = 10.6

BBL-5 (13')
5Y 4/1, reacts w/ HCl, pH = 9.9

BBL-6 ~~(8-10)~~ 8.5-10.5
5Y 4/1, reacts w/ HCl, pH = 10.2
S.C. = 442 µS

BBL-6 ~~(10-12)~~ 10.5-12.5'
5Y 6/1 to 5Y 4/1, reacts w/ HCl,
pH = 10.8 ; S.C. = 1060 µS.

Bay Harbor 11-6-06
CMS

BBL-6 (12.5-14.5')
5Y 4/1, reacts w/ HCl, pH = 11.0
S.C. = 1401 µS

BBL-6 (14.5-15.4')

2.5Y 6/1, reacts w/ HCl, pH = 11.6
S.C. = 4730 µS

1015 - pH recalibrated w/ 7 and 10 buffers.

Note: the pH meter was rechecked against the pH 7.0 buffer between each reading. If a value greater than 7.1 was observed, the meter was fully recalibrated using the 7.0 and 10.0 buffers.

Some residual pore water was present in the sediment samples. Approx 8 oz. of distilled water was added to each sample (similar to 11/2/06 testing procedures).

Location Bay Harbor Date 11-6-06
Project / Client CMS

pH readings (cont.)

BBL-1 (0-2')
5Y 4/2, mostly gravel - some finer material in matrix. pH = 9.5
S.C. = 160 μS

BBL-1 (4-6')
5Y 4/1, same as above; pH = 9.9
S.C. = 400 μS

BBL (8-10')
5Y 4/1, same as above, pH = 10.9
S.C. = 1382 μS

NOTE: not enough sample retained from the 2-4' or 6-8' samples for pH evaluation (gravel only).

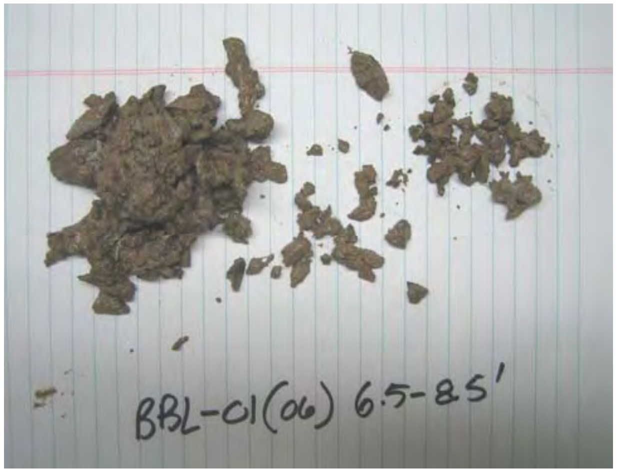
1245 - pH meter recalibrated

MMS 11/6/06

Location
Date
Project / Client

Appendix D

Sediment Sample Photographs



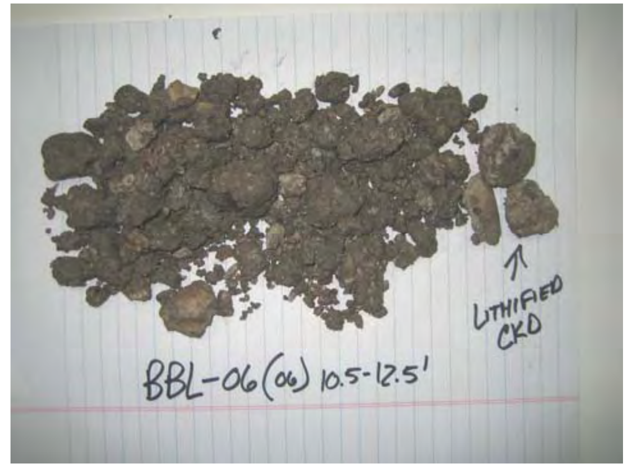
BBL-01(06) 6.5-8.5'

BBL-01(06) 14.5-16.5'

BBL-05(06) 9-11'

BBL-05(06) 11-13'

BBL-06(06) 8.5-10.5’



BBL-06(06) 10.5-12.5’

BBL-06(06) 12.5-14.5’

BBL-06(06) 14.5-15.4’

Appendix C

Geotechnical Sample Results

Barr Footer: Date: 12/8/2006 8:36:54 AM File: I:\Client\CMS\LTB CKD Release Site\Village Harbor\Projects\FS\Fig3 Sediment WQ SampleLocs.mxd User: ksw

- June 2006 Sediment Sample Locations
- September 2006 Sediment Sample Locations
- June 2006 Water Sample Locations
- BBL 2006 Sediment Sample Locations
- Extent of Sump Area (562 ft. contour)
- Bottom Elevation Contour (Top of Soft Sediment)-September 2006

Note: pH listed is the maximum pH observed at sample location.

N

Imagery: April 2005

100 50 0 100 Feet

Figure 3

SEDIMENT AND WATER QUALITY SAMPLE LOCATIONS
Village Harbor
Little Traverse Bay
CKD Release Site
Emmet County, Michigan

MEMORANDUM

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To: Project File - 22816

Date: 12/07/06
Edited 11/27/07

From: Randy Brown

cc:

Re: Geotechnical Sample Results
Village Harbor

This memorandum summarizes results of geotechnical analyses performed on sediment samples collected for Village Harbor at the Little Traverse Bay CKD Release Site, Emmet County, Michigan. The following samples were sent to Materials Testing Consultants, Inc. (Mateco) of Grand Rapids, Michigan, for analysis (Barr Chain-of-Custody forms provided in Attachment A):

Sample	Date Collected	Sample Type	Length, inches
VHARBOR-17-3	9/9/06	1.5" diameter Lexan® core	12.5
VHARBOR-17-4	9/9/06	1.5" diameter Lexan® core	11
VHARBOR-17-2	9/9/06	1.5" diameter Lexan® core	12.5
VHARBOR-17-1	9/9/06	1.5" diameter Lexan® core	14.5
VHARBOR-14	9/7/06	1.5" diameter Lexan® core	12
VHARBOR-15-1	9/8/06	1.5" diameter Lexan® core	8
VHARBOR-15-4	9/8/06	1.5" diameter Lexan® core	12
VHARBOR-15-2	9/8/06	1.5" diameter Lexan® core	12
VHARBOR-14-2	9/8/06	1.5" diameter Lexan® core	16
VHARBOR-14-3	9/8/06	1.5" diameter Lexan® core	16.5
VHARBOR-15-3	9/8/06	1.5" diameter Lexan® core	16
VHARBOR-14	9/8/06	Bulk sample, 1-gallon bucket	N/A
VHARBOR-15	9/8/06	Bulk sample, 1-gallon bucket	N/A
VHARBOR-16	9/9/06	Bulk sample, 5-gallon bucket	N/A
VHARBOR-17	9/9/06	Bulk sample, 1-gallon bucket	N/A

These samples were submitted for analysis for the following:

- Unconfined compressive strength (UCS) via ASTM Method D2166
- Grain Size via ASTM Method D422
- Shear Strength via ASTM Method D3080
- Consolidation via ASTM Method D2435
- Bulk Density via ASTM Method D2937
- Slump Test via ASTM Method C143

In order to conduct these analyses, all available material, including the Lexan® core samples and bulk samples, were utilized to run the required tests. Results are summarized below by test.

Unconfined Compressive Strength (ASTM Method D2166)

Analysis for UCS was performed on five Lexan® core samples: VHARBOR-14-2, VHARBOR-14-3, VHARBOR-15-2, VHARBOR-17-1, and VHARBOR-17-2. Test reports are included in Attachment B.

The UCS for the five samples ranged from 0.69 pounds per square inch (psi) to 2.31 psi. The samples with lower unconfined strength corresponded to the samples with the highest water content. UCS results are summarized in the following table.

Sample	Unconfined Strength, psi	Undrained Shear Strength, psi	Water Content, %
VHARBOR-14-2	2.31	1.15	40.0
VHARBOR-14-3	1.89	0.95	50.2
VHARBOR-15-2	0.98	0.49	82.2
VHARBOR-17-1	0.70	0.35	197.1
VHARBOR-17-2	0.69	0.34	259.5

Grain Size (ASTM Method D422)

Analysis for grain size distribution was performed on six Lexan® core samples: VHARBOR-14-2, VHARBOR-14-3, VHARBOR-15-2, VHARBOR-15-4, VHARBOR-17-1, and VHARBOR-17-2. Test reports are included in Attachment C.

Grain size results indicated that the majority of each sample was comprised of silt and clay-sized particles, with over 90% of the material for each of the six samples passed a #200 sieve. Grain size results are summarized in the following table.

Sample	% Gravel	% Sand	% Silt	% Clay
VHARBOR-14-2	3.4	2.5	47.1	47.0
VHARBOR-14-3	6.2	1.8	45.8	46.2
VHARBOR-15-2	0.0	5.1	61.3	33.6
VHARBOR-15-4	0.6	4.4	61.6	33.4
VHARBOR-17-1	0.0	6.3	67.9	25.8
VHARBOR-17-2	0.0	4.2	63.5	32.3

Direct Shear Strength (ASTM Method D3080)

Analysis for direct shear strength was performed on the three 1-gallon bulk samples: VHARBOR-14, VHARBOR-15, and VHARBOR-17. Test reports are included in Attachment D, and summarized in the following table (all values in pounds per square foot [psf] except the internal friction angle [degrees]).

Sample	Ultimate Stress, Sample 1	Ultimate Stress, Sample 2	Ultimate Stress, Sample 3	Cohesion (C)	Internal Friction Angle (Φ) (deg.)
VHARBOR-14	459	718	1,052	90.3	30.7
VHARBOR-15	459	758	1,042	111	30.3
VHARBOR-17	349	648	1,007	0	31.5

Consolidation (ASTM Method D2435) and Bulk Density (ASTM Method D2937)

Analyses for consolidation and bulk density were performed on the three 1-gallon bulk samples: VHARBOR-14, VHARBOR-15, and VHARBOR-17. Test reports are included in Attachment E, and summarized in the following table.

Sample	Dry Density ($lbs./ft^3$)	e_o	P_c, ($lbs./ft^2$)	Compression Index, Cc	Recompression Index, Cr
VHARBOR-14	42.7	2.910	653	0.47	0.03
VHARBOR-15	25.7	5.571	207	0.34	0.03
VHARBOR-17	51.8	2.255	958	1.30	0.05

Slump Test (ASTM Method C143)

The 5-gallon bulk sample (VHARBOR-16) was combined with all remaining material from the Lexan® core samples and 1-gallon bulk samples, and utilized to perform a slump test via ASTM Method C143. Mateco laboratory personnel has verbally reported preliminary results of 2-3 inches for the slump test result using this combined bulk sample. Mateco indicated that the bulk sample exhibited a tendency to stick to the test apparatus, and that the laboratory would evaluate measures to relieve this tendency to stick and re-run the test. Results of the re-run of this slump test are pending.

RRB/rrb

Attachment A

Barr Chain-of-Custody Forms

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BARR

Chain of Custody

4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

Project Number: 22/24-001 EKK3200

Project Name: BAY HARBOR

№ 22850

COC 1 of 1

Project Manager: EKK

Project Contact: KDP

Sampled by: MMB/NJB/LMG

Laboratory: ~~SET~~ EJS BBL

Sample Identification	Collection Date	Collection Time	Matrix: Water	Matrix: Soil	Type: Grab	Type: Comp.	Type: QC	Water: Volatile Organics (Pres.) *1	Water: Semivolatile Organics *2	Water: Dissolved Metals (HNO_3)	Water: Total Metals (HNO_3)	Water: General (Unpreserved) *3	Water: Cyanide (NaOH)	Water: Nutrients (H_2SO_4) *4	Water: Oil and Grease (H_2SO_4)	Water: Sulfide (Zn Acetate)	Water: Methane	Water: Bacteria ($Na_2S_2O_3$)	Water: DRO (HCl)	Soil: VOCs (2-oz tared MeOH) *1	Soil: GRO, BTEX (2-oz tared MeOH) *1	Soil: DRO (2-oz tared) - 25 grams	Soil: Metals (2-oz unpreserved)	Soil: SVOCs (2 or 4-oz unpres.) *2	Soil: % Moisture (plastic vial, unpres.)	Total No. Of Containers	Remarks: CORELENGTH
1. VHARBOR-17-3	9/9/06	1300		X	X																					1	CALL DALE 12.5
2. VHARBOR-17-4	9/9/06	1315		X	X																					1	KOHLSTAD AT 11
3. VHARBOR-17-2	9/9/06	1200		X	X																					1	BARR FOR 12.5
4. VHARBOR-17-1	9/9/06	1140		X	X																					1	PARAMETERS 14.5
5. VHARBOR-14 ~~3~~ EJS	9/7/06	1430		X	X																					1	12
6. VHARBOR-15-1	9/8/06	1200		X	X																					1	952 832-2690 8
7. VHARBOR-15-4	9/8/06	1330		X	X																					1	12
8. VHARBOR-15-2	9/8/06	1230		X	X																					1	12
9. VHARBOR-14-2	9/8/06	0900		X	X																					1	16
10. VHARBOR-14-3	9/8/06	1000			X																					1	16.5
11. VHARBOR-15-3	9/8/06	1300		X	X																					1	16
12.																											

Common Parameter/Container - Preservation Key

*1 - Volatile Organics = BTEX, GRO, TPH, Full List
*2 - Semivolatile Organics = PAHs, PCP, Dioxins, Full List, Herbicide/Pesticide/PCBs
*3 - General = pH, Chloride, Flouride, Alkalinity, TSS, TDS, TS, Sulfate
*4 - Nutrients = COD, TOC, Phenols, Ammonia Nitrogen, TKN

Relinquished By:	On Ice?	Date	Time	Received by:	Date	Time
[signature]	Y (N)	9/9/06	1000	[signature]	9/14/6	5:05 PM
Relinquished By:	On Ice? Y N	Date	Time	Received by:	Date	Time

Samples Shipped VIA: ☐ Air Freight ☐ Federal Express ☐ Sampler ☐ Other ______

Air Bill Number:

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy; Pink - Lab Coordinator

BARR

Chain of Custody

4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

Project Number: 22/24-001 EKK3200

Project Name: Bay Harbor

№ 22855

COC 1 of 2

Project Manager: EKK

Project Contact: KDP

Sampled by: NJB, MMB, LMG

Laboratory: ~~SEF~~ EJS BBL

Number of Containers/Preservative

#	Sample Identification	Collection Date	Collection Time	Matrix: Water	Matrix: Soil	Type: Grab	Type: Comp.	Type: QC	Water: Volatile Organics (Pres.)*1	Water: Semivolatile Organics *2	Water: Dissolved Metals (HNO_3)	Water: Total Metals (HNO_3)	Water: General (Unpreserved) *3	Water: Cyanide (NaOH)	Water: Nutrients (H_2SO_4) *4	Water: Oil and Grease (H_2SO_4)	Water: Sulfide (Zn Acetate)	Water: Methane	Water: Bacteria ($Na_2S_2O_3$)	Water: DRO (HCl)	Soil: VOCs (2-oz tared MeOH)*1	Soil: GRO, BTEX (2-oz tared MeOH)*1	Soil: DRO (2-oz tared) - 25 grams	Soil: Metals (2-oz unpreserved)	Soil: SVOCs (2 or 4-oz unprcs.)*2	Soil: % Moisture (plastic vial, unprcs.)	1-gallon bucket	Total No. Of Containers	Remarks
1.	VHARBOR-14	9/8/06	1010		X	X	~~X~~																				1	1	bulk samples, contact KDP with questions 800-632-2277
2.	VHARBOR-15	9/8/06	1330		X	X																					1	1	
3.																													
4.																													
5.																													
6.																													
7.																													
8.																													
9.																													
10.																													
11.																													
12.																													

Relinquished By	On Ice? Y N	Date	Time	Received by	Date	Time
[signature] M. Gruber	N	9/11/06	0900	[signature]	9-14-06	5:05 PM

Samples Shipped VIA: ☐ Air Freight ☐ Federal Express ☐ Sampler ☐ Other ____

Air Bill Number:

Common Parameter/Container - Preservation Key

*1 - *Volatile Organics = BTEX, GRO, TPH, Full List*
*2 - *Semivolatile Organics = PAHs, PCP, Dioxins, Full List, Herbicide/Pesticide/PCBs*
*3 - *General = pH, Chloride, Flouride, Alkalinity, TSS, TDS, TS, Sulfate*
*4 - *Nutrients = COD, TOC, Phenols, Ammonia Nitrogen, TKN*

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy; Pink - Lab Coordinator

BARR

Chain of Custody

4700 West 77th Street
Minneapolis, MN 55435-4803
(952) 832-2600

COC 2 of 2

Project Number: 22/24-001 EKK3200

Project Name: Bay Harbor

№ 22856

Project Manager: EKK

Project Contact: KDP

Sampled by: NJB, MMB, LMG

Laboratory: ~~SET~~ EJS BBL

Number of Containers/Preservative

	Sample Identification	Collection Date	Collection Time	Matrix: Water	Matrix: Soil	Type: Grab	Type: Comp.	Type: QC	Water: Volatile Organics (Pres.) *1	Water: Semivolatile Organics *2	Water: Dissolved Metals (HNO_3)	Water: Total Metals (HNO_3)	Water: General (Unpreserved) *3	Water: Cyanide (NaOH)	Water: Nutrients (H_2SO_4) *4	Water: Oil and Grease (H_2SO_4)	Water: Sulfide (Zn Acetate)	Water: Methane	Water: Bacteria ($Na_2S_2O_3$)	Water: DRO (HCl)	Soil: VOCs (2-oz tared MeOH) *1	Soil: GRO, BTEX (2-oz tared MeOH) *1	Soil: DRO (2-oz tared) - 25 grams	Soil: Metals (2-oz unpreserved)	Soil: SVOCs (2 or 4-oz unpres.) *2	Soil: % Moisture (plastic vial, unpres.)	5-gallon bucket	1-gallon bucket	Total No. Of Containers	Remarks
1.	VHARBOR-16	9/9/06	1000		X	X																					1		1	bulk samples; contact KDP w/ questions 800-632-2277
2.	VHARBOR-17	9/9/06	1330		X	X																						1	1	
3.																														
4.																														
5.																														
6.																														
7.																														
8.																														
9.																														
10.																														
11.																														
12.																														

Common Parameter/Container - Preservation Key

*1 - Volatile Organics = BTEX, GRO, TPH, Full List
*2 - Semivolatile Organics = PAHs, PCP, Dioxins, Full List, Herbicide/Pesticide/PCBs
*3 - General = pH, Chloride, Flouride, Alkalinity, TSS, TDS, TS, Sulfate
*4 - Nutrients = COD, TOC, Phenols, Ammonia Nitrogen, TKN

Relinquished By	On Ice? Y N	Date	Time	Received by	Date	Time
Leah M. Gruhn	N	9/11/06	0900	[illegible signature]	9-14-06	5:05 PM

Samples Shipped VIA: ☐ Air Freight ☐ Federal Express ☐ Sampler ☐ Other ______

Air Bill Number:

Distribution: White-Original Accompanies Shipment to Lab; Yellow - Field Copy; Pink - Lab Coordinator

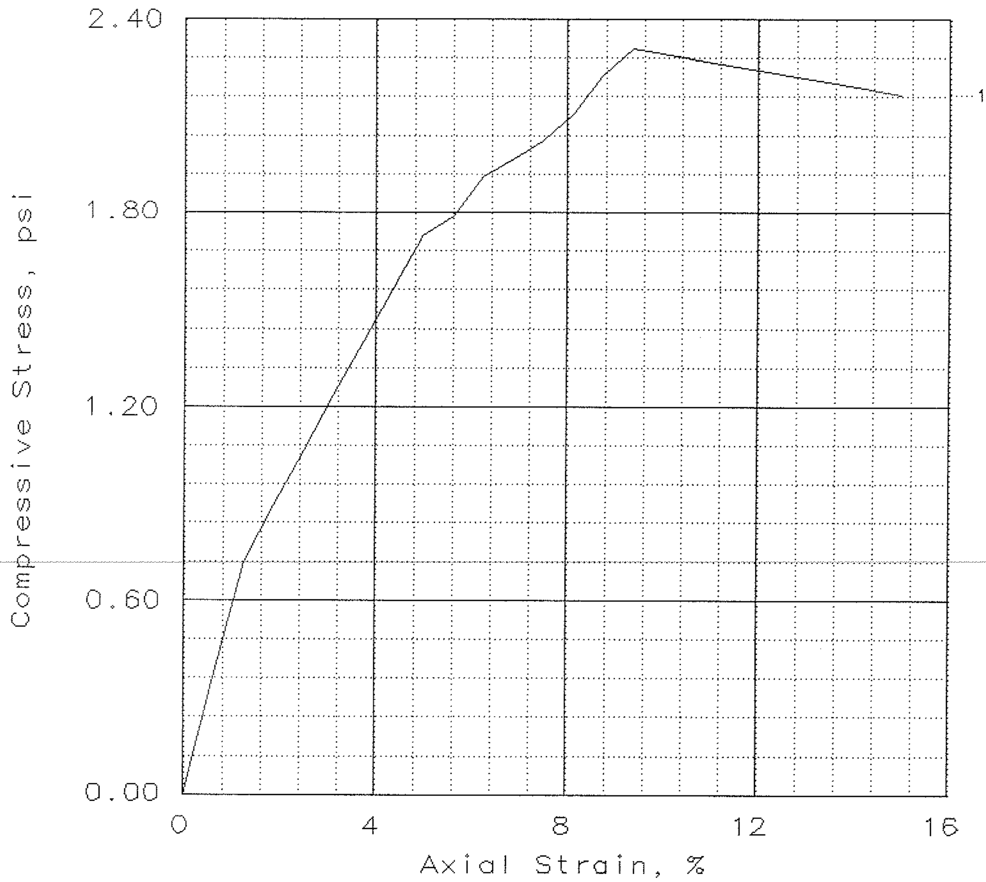
H:RLG\STDFORMS\Chain Of Custody Form RLG Rev. 07/01/05

Attachment B

Unconfined Compressive Strength Test Results

an ARCADIS company

UNCONFINED COMPRESSION TEST



SAMPLE NO.:	1			
Unconfined strength, psi	2.31			
Undrained shear strength, psi	1.15			
Failure strain, %	9.4			
Strain rate, %/min	2.00			
Water content, %	40.0			
Wet density, pcf	113.4			
Dry density, pcf	81.0			
Saturation, %	99.9			
Void ratio	1.0808			
Specimen diameter, in	1.87			
Specimen height, in	4.00			
Height/diameter ratio	2.14			

Description: Silt

			GS= 2.7	Type: Lexan core

Project No.: 061420
Date: 10/31/06
Remarks:
MTC Sample No. 82581

Fig. No.: ____

Client: BBL

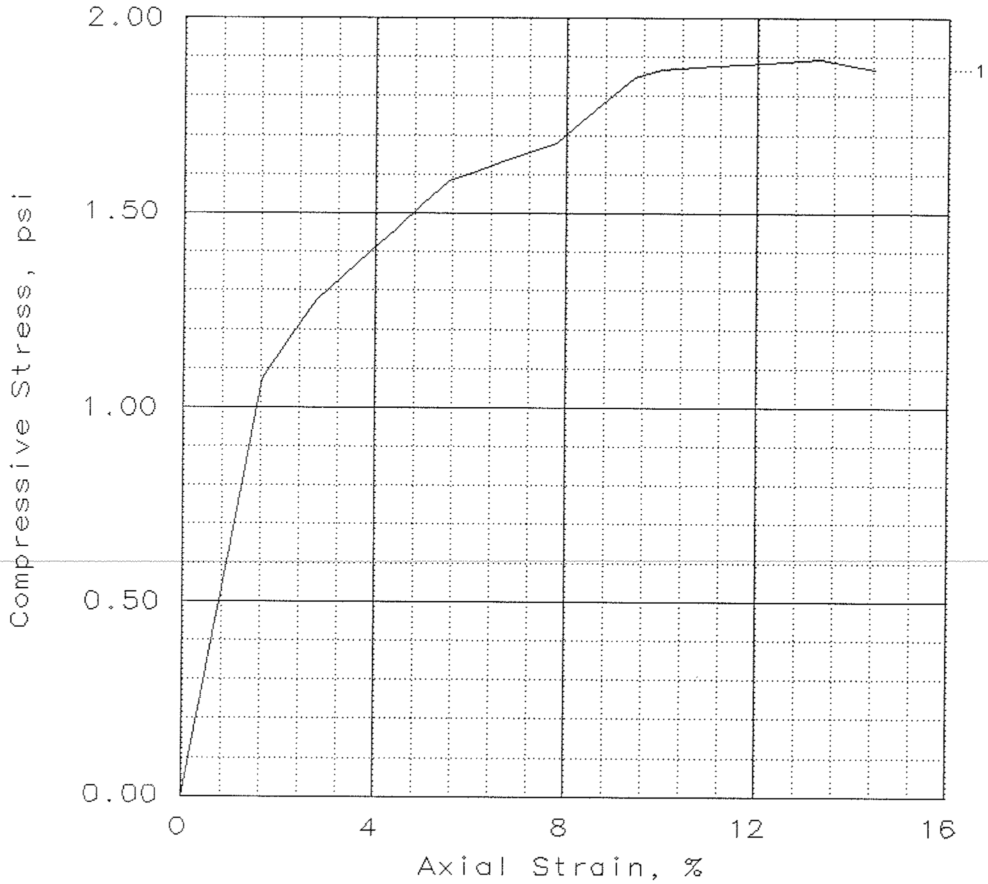
Project: Bay Harbor

Location: VHARBOR-14-2

UNCONFINED COMPRESSION TEST

MATERIALS TESTING CONSULTANTS

UNCONFINED COMPRESSION TEST



SAMPLE NO.:	1			
Unconfined strength, psi	1.89			
Undrained shear strength, psi	0.95			
Failure strain, %	13.3			
Strain rate, %/min	2.00			
Water content, %	50.2			
Wet density, pcf	107.4			
Dry density, pcf	71.5			
Saturation, %	99.9			
Void ratio	1.3564			
Specimen diameter, in	1.87			
Specimen height, in	4.50			
Height/diameter ratio	2.41			

Description: Silt

			GS= 2.7	Type: Lexan core

Project No.: 061420
Date: 10/31/06
Remarks:
MTC Sample No. 82582

Fig. No.: ______

Client: BBL

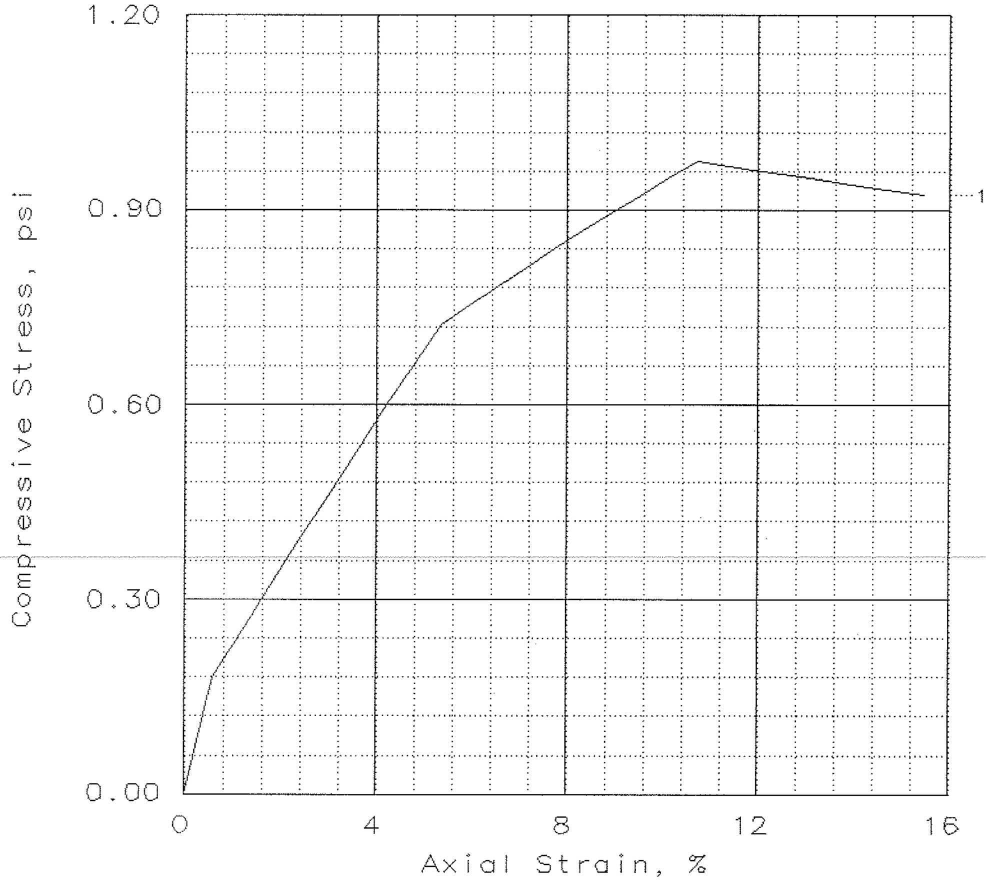
Project: Bay Harbor

Location: VHARBOR-14-3

UNCONFINED COMPRESSION TEST

MATERIALS TESTING CONSULTANTS

UNCONFINED COMPRESSION TEST



SAMPLE NO.:	1			
Unconfined strength, psi	0.98			
Undrained shear strength, psi	0.49			
Failure strain, %	10.7			
Strain rate, %/min	2.00			
Water content, %	82.2			
Wet density, pcf	95.3			
Dry density, pcf	52.3			
Saturation, %	99.9			
Void ratio	2.2212			
Specimen diameter, in	1.87			
Specimen height, in	4.20			
Height/diameter ratio	2.25			

Description: Silt

GS= 2.7 | Type: Lexan core

Project No.: 061420
Date: 10/31/06

Remarks:
MTC Sample No. 82583

Fig. No.: ______

Client: BBL

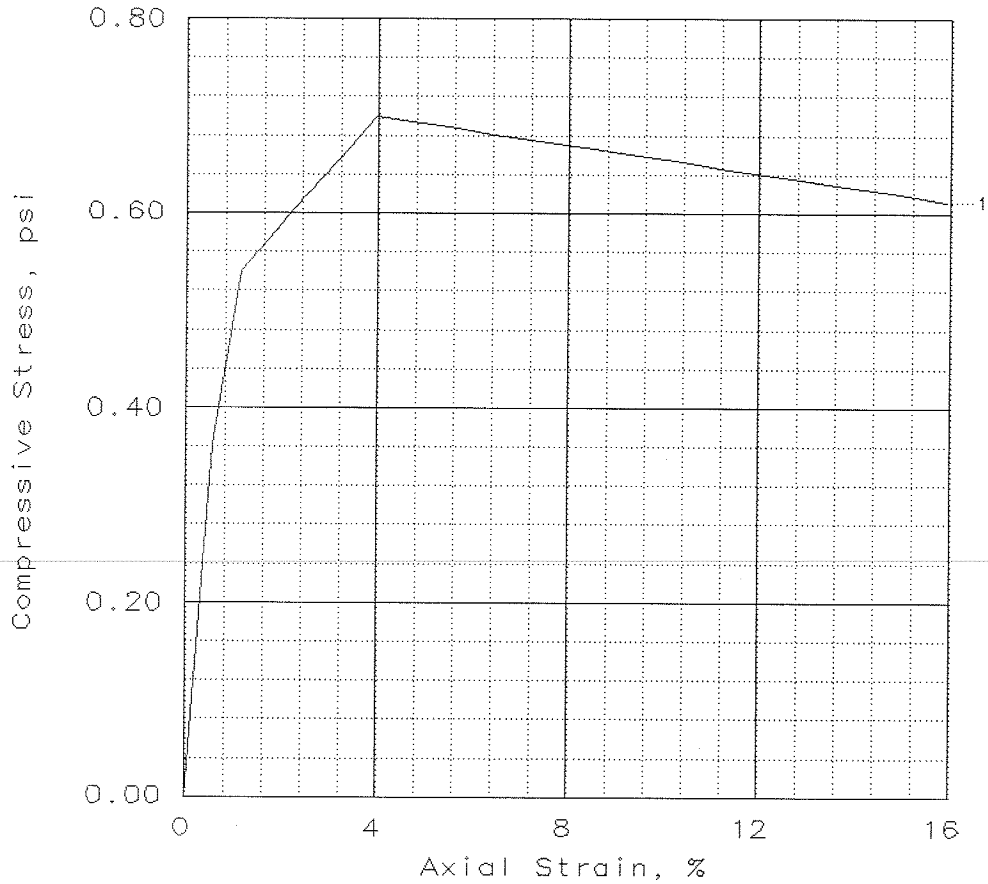
Project: Bay Harbor

Location: VHARBOR-15-2

UNCONFINED COMPRESSION TEST

MATERIALS TESTING CONSULTANTS

UNCONFINED COMPRESSION TEST



SAMPLE NO.:	1			
Unconfined strength, psi	0.70			
Undrained shear strength, psi	0.35			
Failure strain, %	4.0			
Strain rate, %/min	2.00			
Water content, %	197.1			
Wet density, pcf	79.2			
Dry density, pcf	26.6			
Saturation, %	99.9			
Void ratio	5.3271			
Specimen diameter, in	1.87			
Specimen height, in	4.40			
Height/diameter ratio	2.35			

Description: Silt

GS= 2.7 | Type: Lexan core

Project No.: 061420
Date: 10/31/06

Remarks:
MTC Sample No. 82585

Fig. No.: ______

Client: BBL

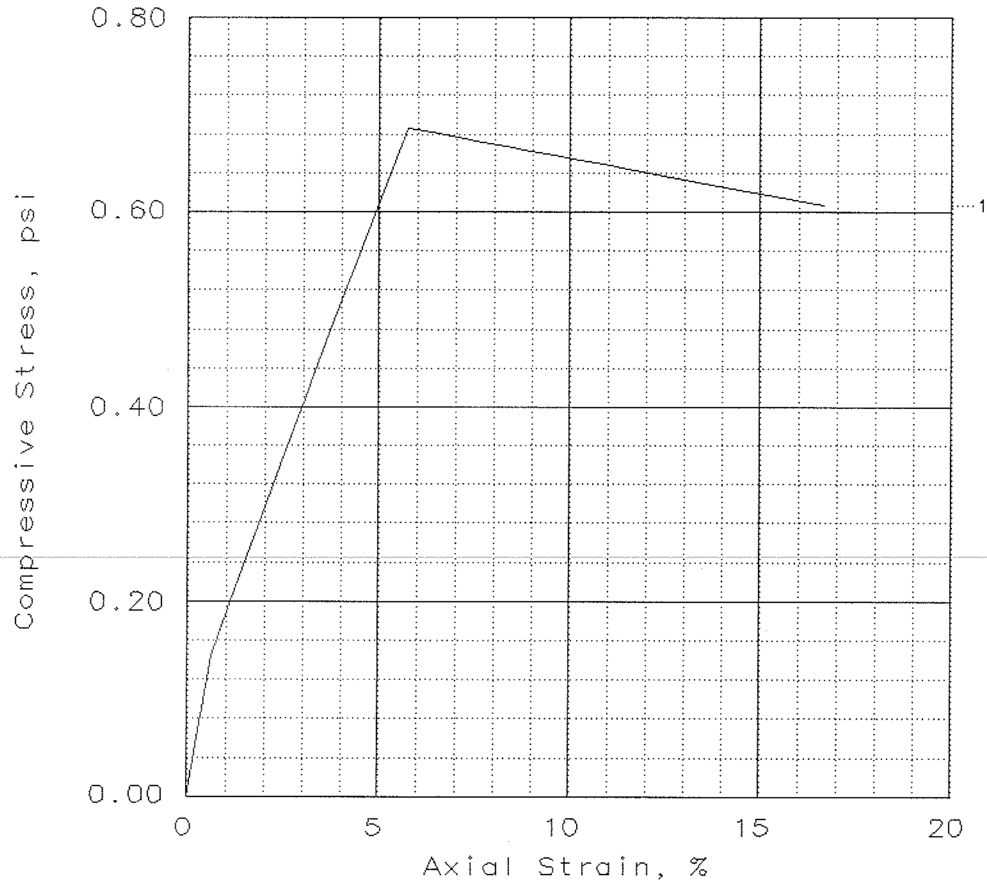
Project: Bay Harbor

Location: VHARBOR-17-1

UNCONFINED COMPRESSION TEST

MATERIALS TESTING CONSULTANTS

UNCONFINED COMPRESSION TEST



SAMPLE NO.:	1			
Unconfined strength, psi	0.69			
Undrained shear strength, psi	0.34			
Failure strain, %	5.8			
Strain rate, %/min	2.00			
Water content, %	259.5			
Wet density, pcf	75.6			
Dry density, pcf	21.0			
Saturation, %	99.9			
Void ratio	7.0144			
Specimen diameter, in	1.87			
Specimen height, in	3.90			
Height/diameter ratio	2.09			

Description: Silt

GS= 2.7 | Type: Lexan core

Project No.: 061420
Date: 10/31/06

Remarks:
MTC Sample No. 82586

Fig. No.: ______

Client: BBL

Project: Bay Harbor

Location: VHARBOR-17-2

UNCONFINED COMPRESSION TEST

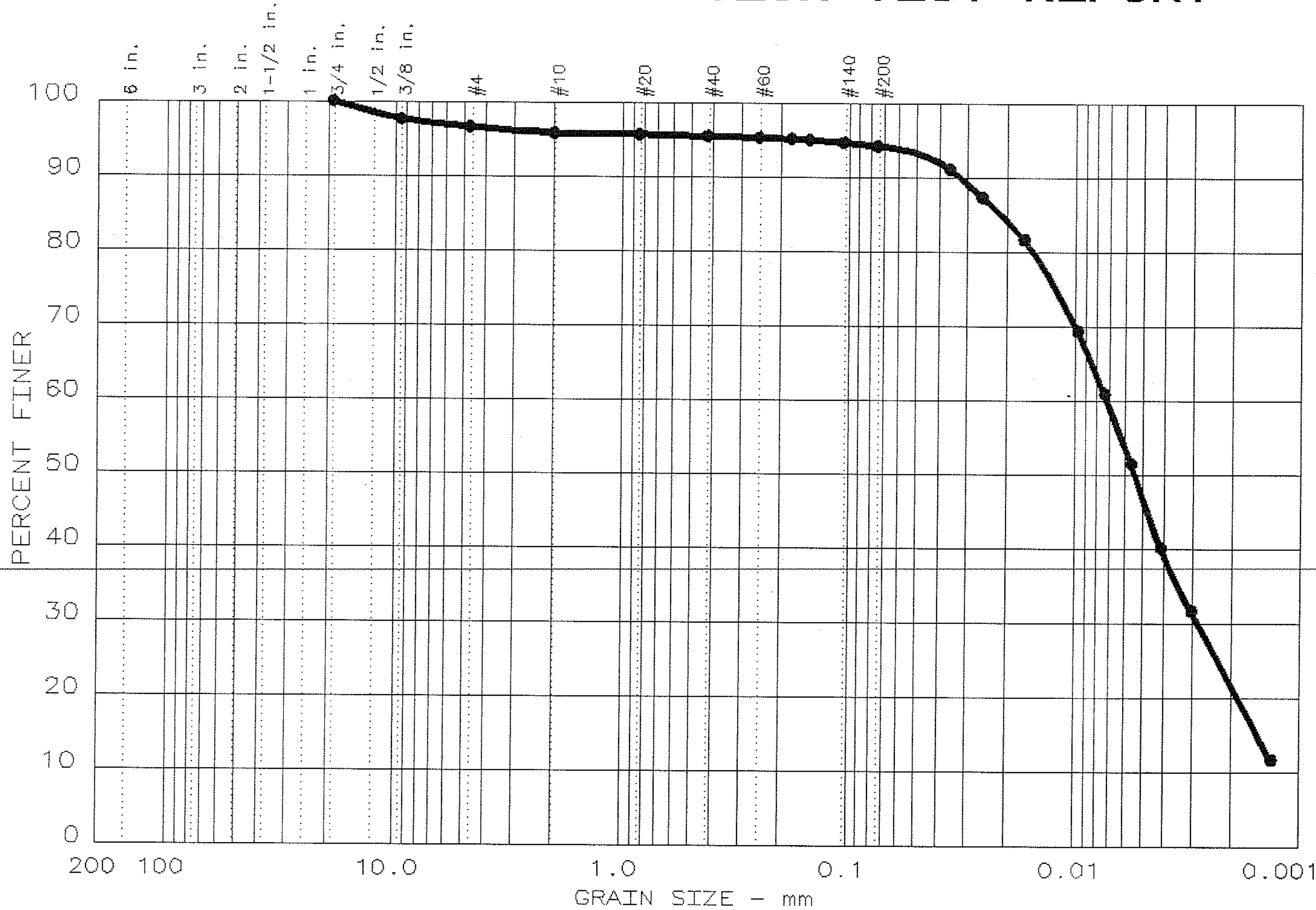
MATERIALS TESTING CONSULTANTS

Attachment C

Grain Size Distribution Test Results

an ARCADIS company

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	3.4	2.5	47.1	47.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●					0.0054	0.0028	0.0015			

MATERIAL DESCRIPTION	USCS	AASHTO
● Silt	ML	

Project No.: 061420
Project: Bay Harbor
● Location: VHarbor-14-2

Date: 10/31/06

GRAIN SIZE DISTRIBUTION TEST REPORT

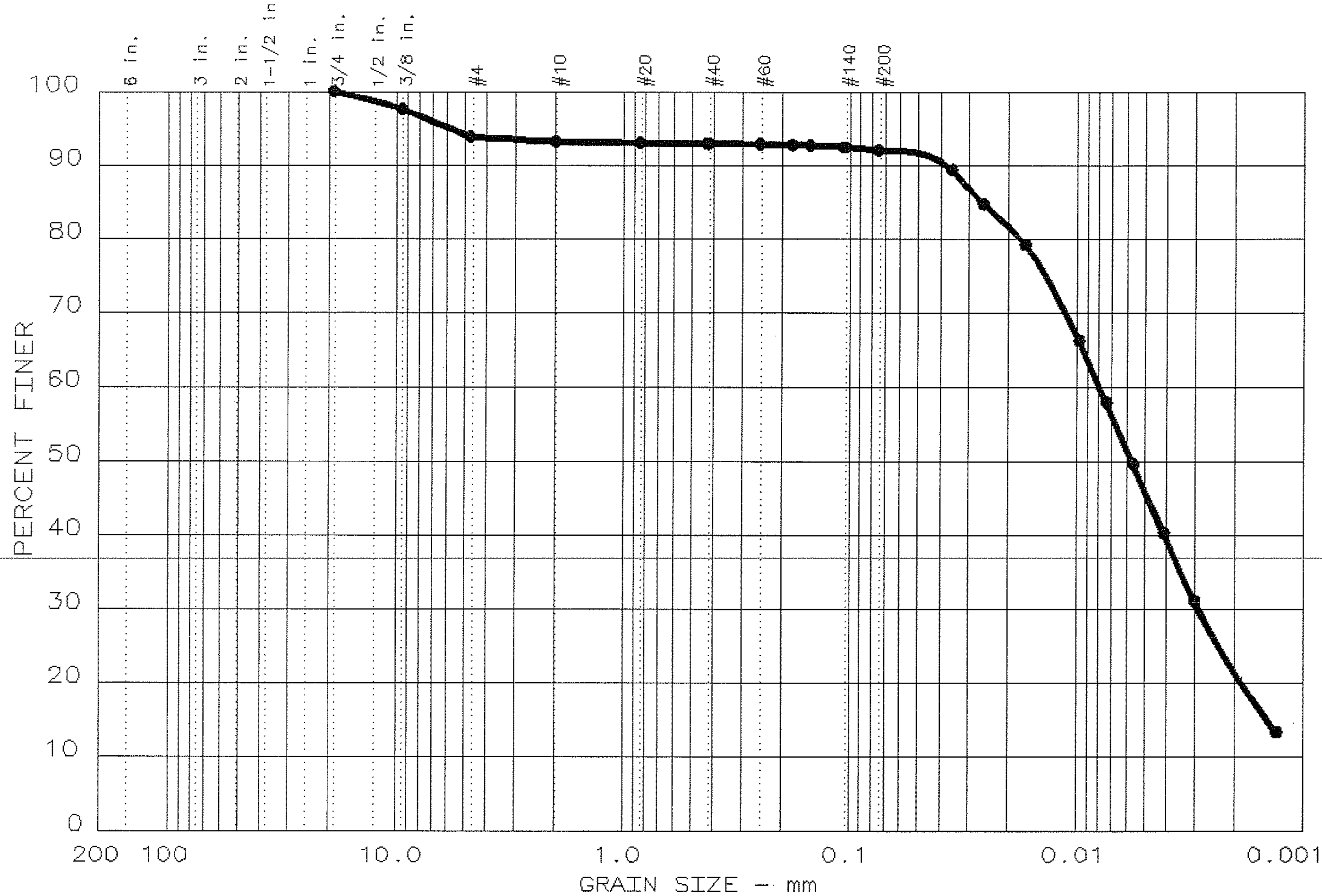
MATERIALS TESTING CONSULTANTS

Remarks:

MTC Sample No. 82581

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	6.2	1.8	45.8	46.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●					0.0057	0.0029	0.0014			

MATERIAL DESCRIPTION	USCS	AASHTO
● Silt	ML	

Project No.: 061420
Project: Bay Harbor
● Location: VHarbor-14-3

Date: 10/31/06

GRAIN SIZE DISTRIBUTION TEST REPORT

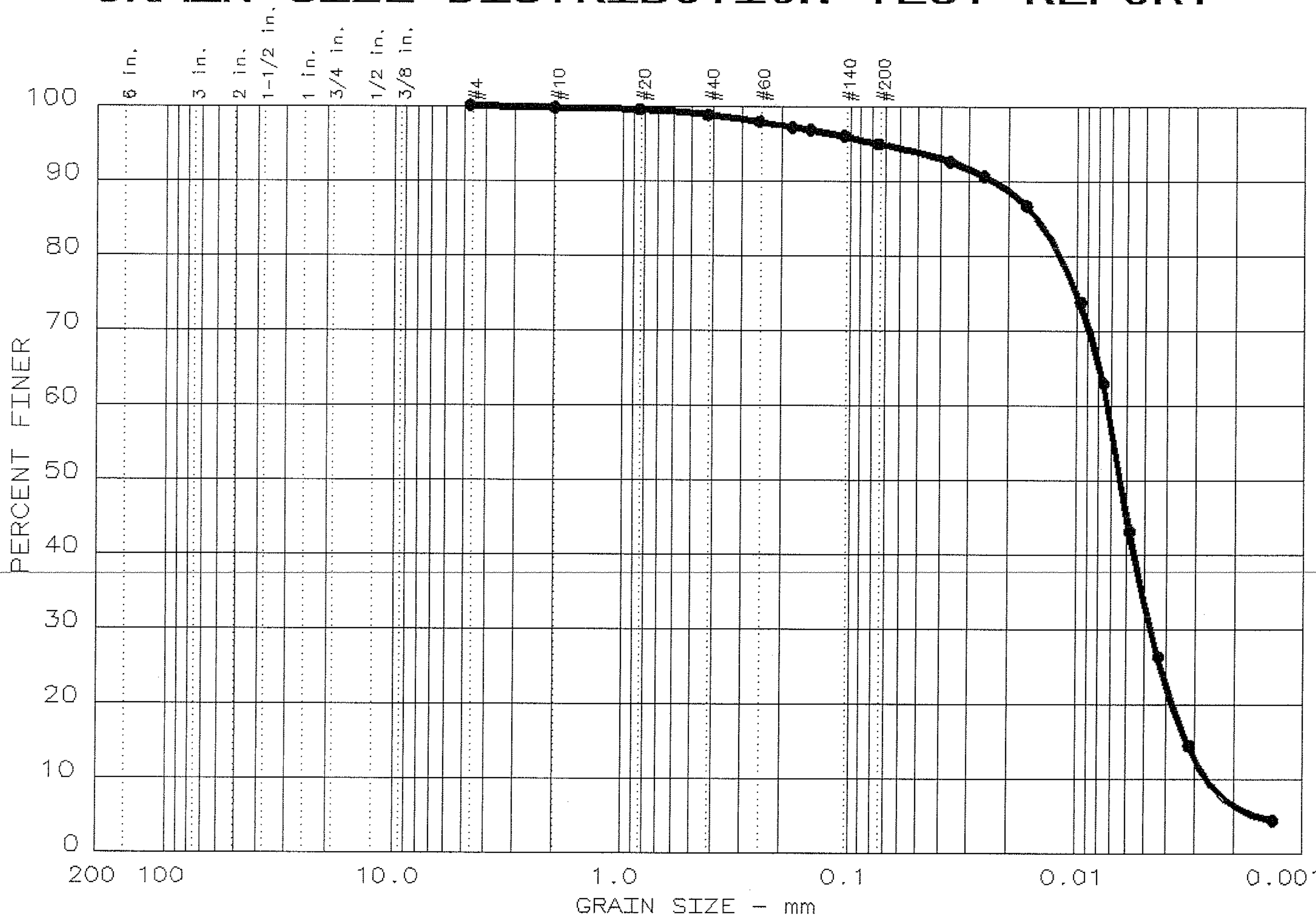
MATERIALS TESTING CONSULTANTS

Remarks:

MTC Sample No. 82582

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	5.1	61.3	33.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●					0.0064	0.0047	0.0032	0.0026	1.15	2.8

MATERIAL DESCRIPTION	USCS	AASHTO
● Silt	ML	

Project No.: 061420
Project: Bay Harbor
● Location: VHarbor-15-2

Date: 10/31/06

Remarks:

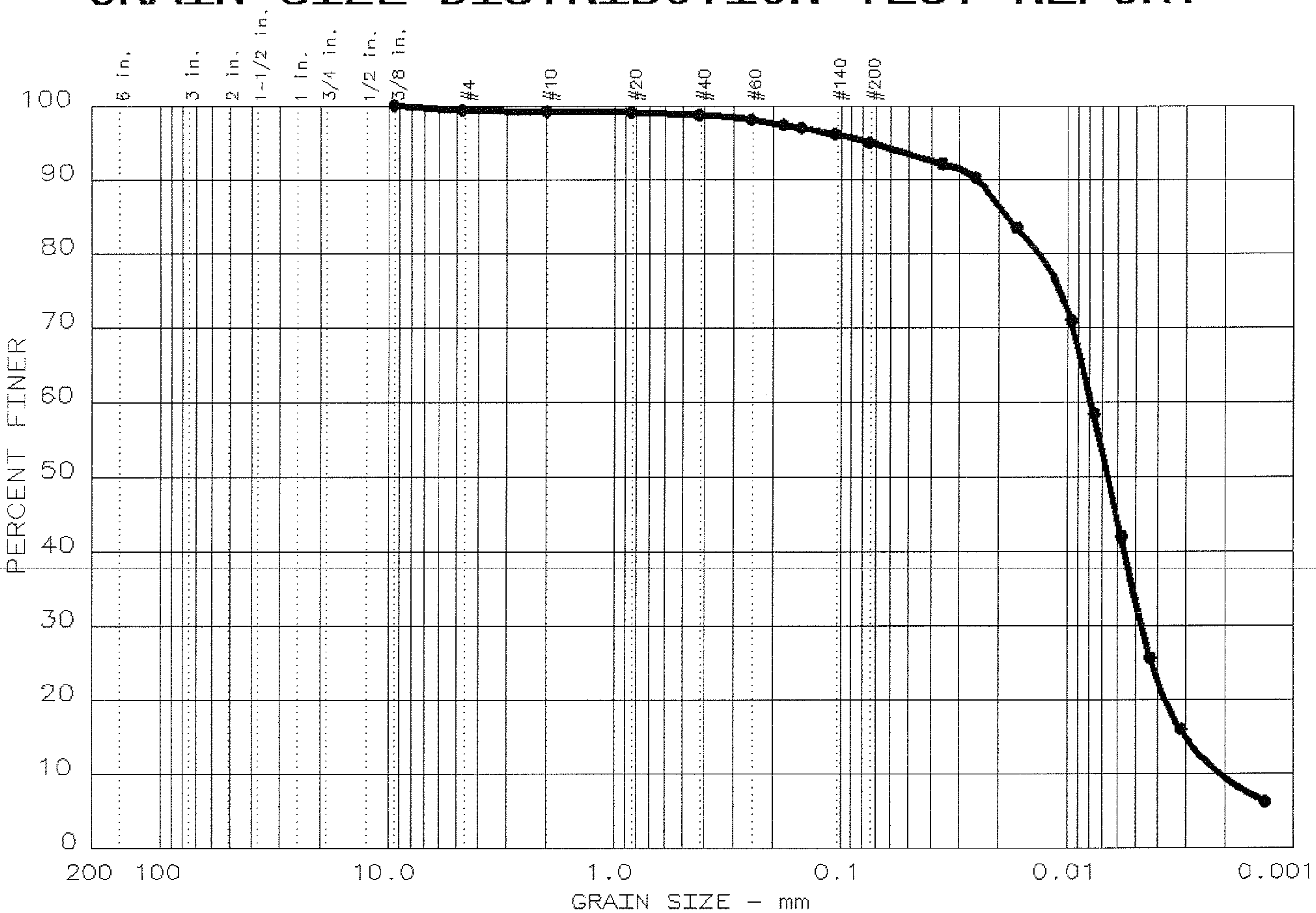
MTC Sample No. 82583

GRAIN SIZE DISTRIBUTION TEST REPORT

MATERIALS TESTING CONSULTANTS

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.6	4.4	61.6	33.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●					0.0066	0.0047	0.0030	0.0021	1.34	3.7

MATERIAL DESCRIPTION	USCS	AASHTO
● Silt	ML	

Project No.: 061420
Project: Bay Harbor
● Location: VHarbor-15-4

Date: 10/31/06

Remarks:

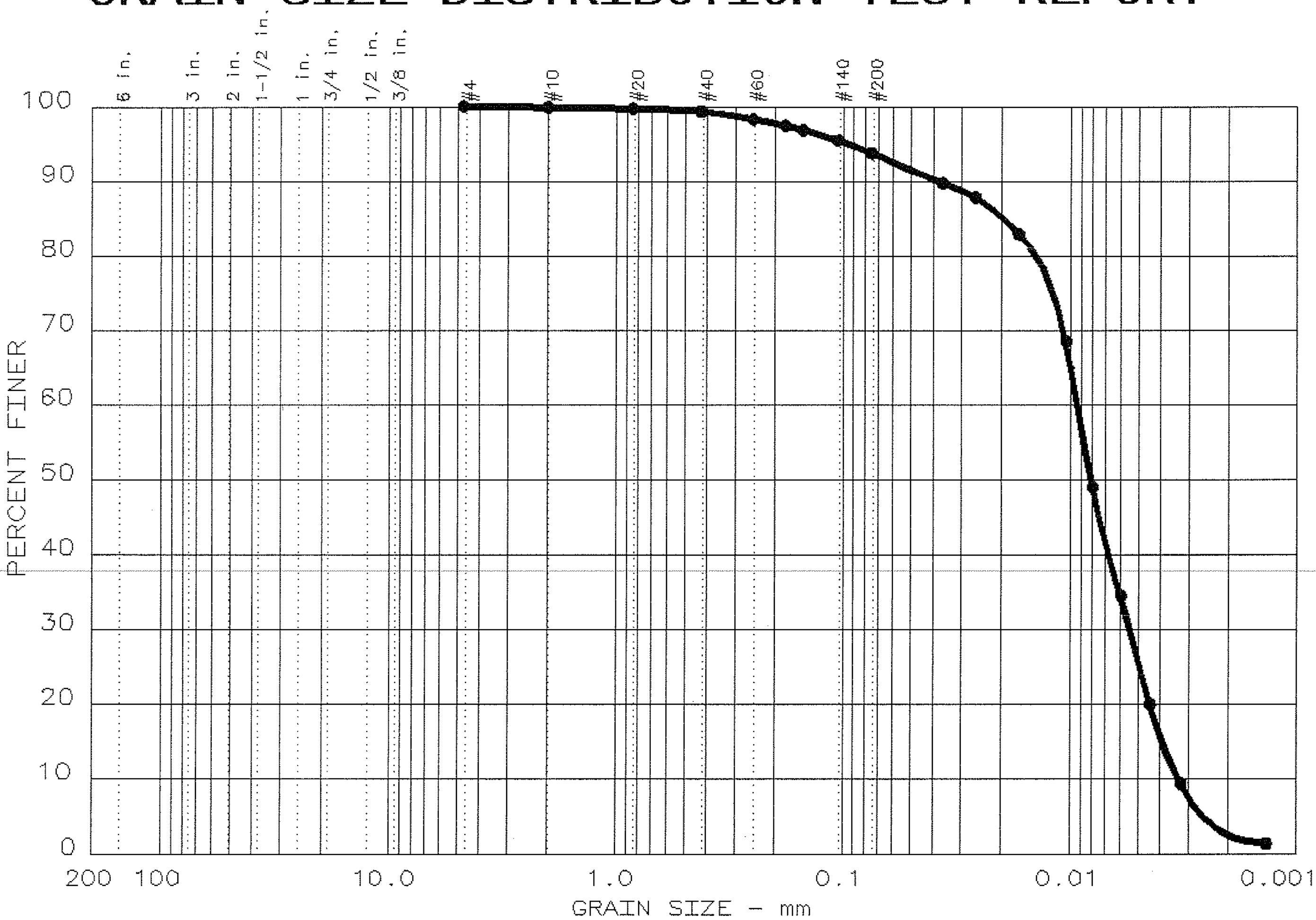
MTC Sample No. 82584

GRAIN SIZE DISTRIBUTION TEST REPORT

MATERIALS TESTING CONSULTANTS

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	6.3	67.9	25.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●					0.0081	0.0054	0.0039	0.0033	0.96	2.8

MATERIAL DESCRIPTION	USCS	AASHTO
● Silt	ML	

Project No.: 061420
Project: Bay Harbor
● Location: VHarbor-17-1

Date: 10/31/06

GRAIN SIZE DISTRIBUTION TEST REPORT

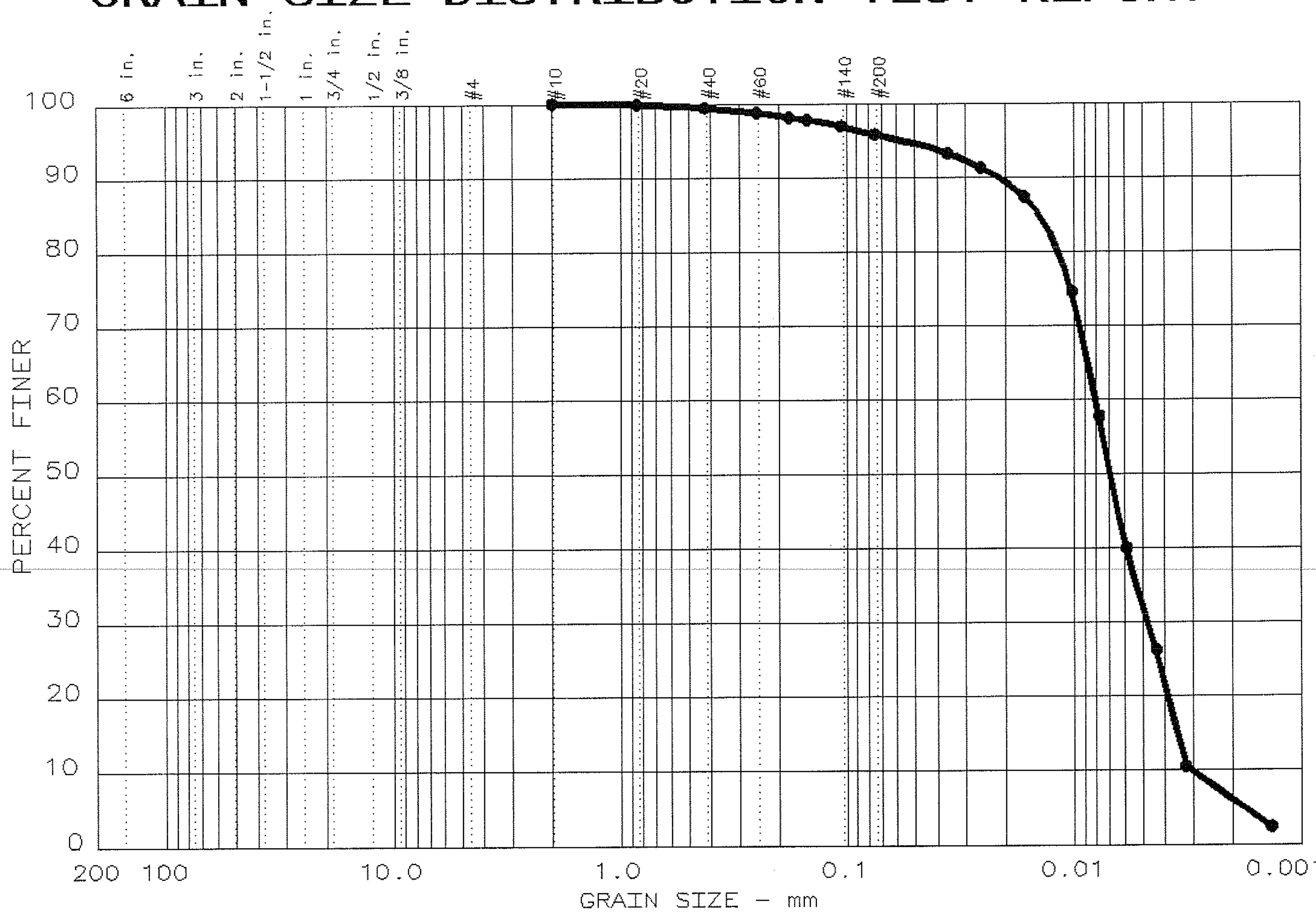
MATERIALS TESTING CONSULTANTS

Remarks:

MTC Sample No. 82585

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	4.2	63.5	32.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●					0.0069	0.0047	0.0035	0.0031	0.91	2.6

MATERIAL DESCRIPTION	USCS	AASHTO
● Silt	ML	

Project No.: 061420
Project: Bay Harbor
● Location: VHarbor-17-2

Date: 10/31/06

Remarks:

MTC Sample No. 82586

GRAIN SIZE DISTRIBUTION TEST REPORT

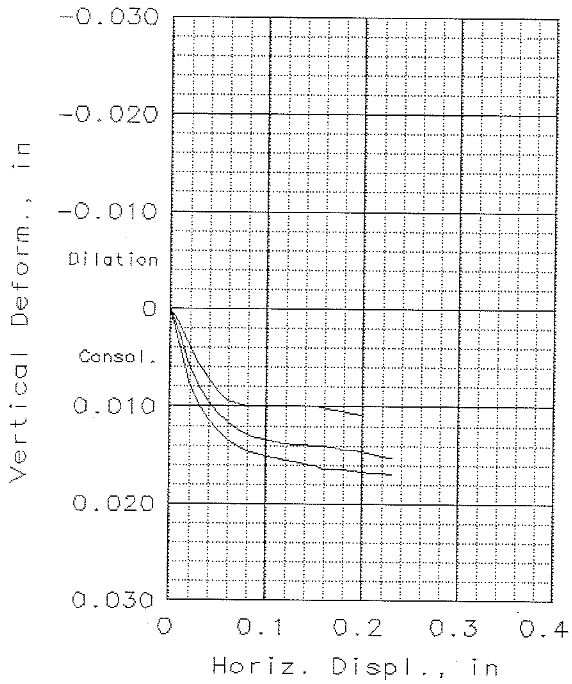
MATERIALS TESTING CONSULTANTS

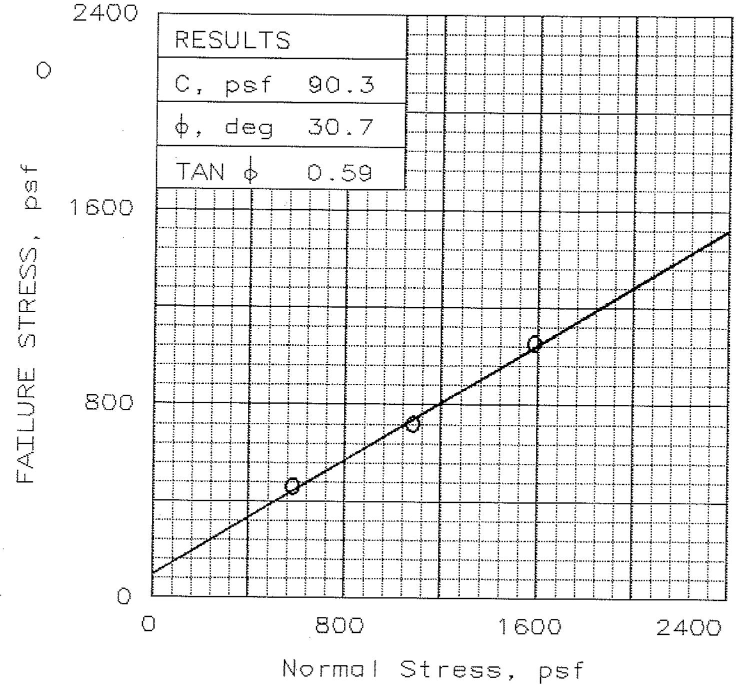
Fig. No.: ______

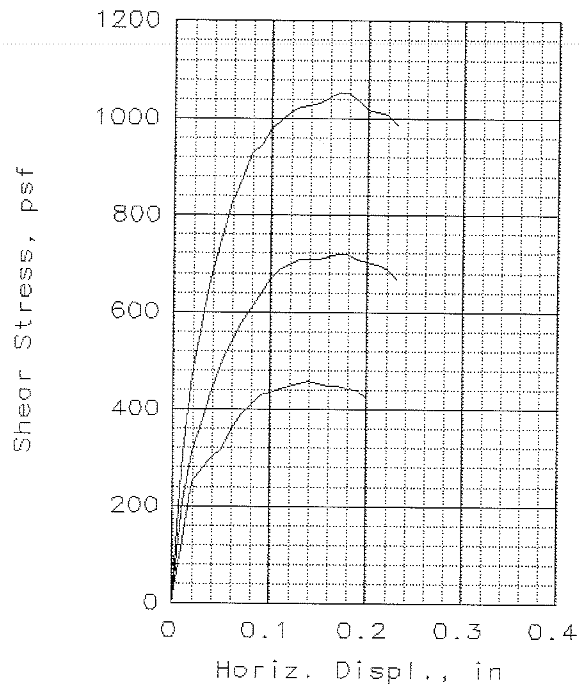
Attachment D

Direct Shear Test Results

BBL®
an ARCADIS company







SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	47.9	47.9	47.9
	DRY DENSITY, pcf	73.5	73.5	73.5
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	1.293	1.293	1.293
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.11	1.11	1.11
AT TEST	WATER CONTENT, %	39.8	38.7	38.3
	DRY DENSITY, pcf	79.7	80.6	81.1
	SATURATION, %	96.5	95.7	96.1
	VOID RATIO	1.114	1.093	1.077
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.02	1.01	1.01
NORMAL STRESS, psf		600	1100	1600
FAILURE STRESS, psf		459	718	1052
DISPLACEMENT, in		0.14	0.17	0.17
ULTIMATE STRESS, psf		459	718	1052
DISPLACEMENT, in		0.14	0.17	0.18
Strain rate, %/min		0.10	0.10	0.10

SAMPLE TYPE: 1 Gallon Pail
DESCRIPTION: Silt

SPECIFIC GRAVITY= 2.7
REMARKS: MTC Sample No. 83236

Fig. No.: ______

CLIENT: BBL

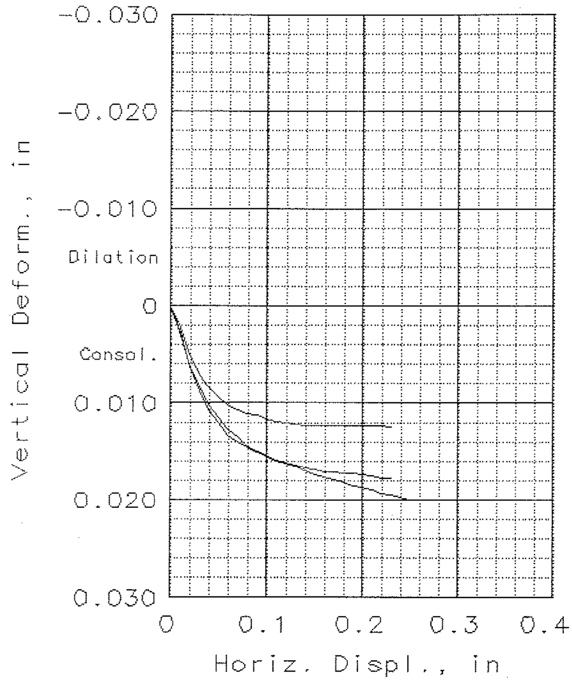
PROJECT: Bay Harbor

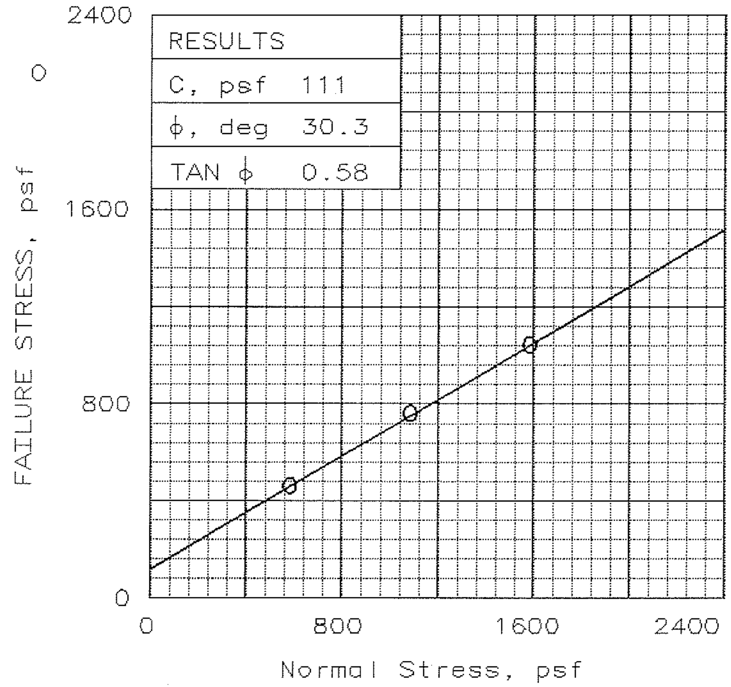
SAMPLE LOCATION: VHARBOR-14

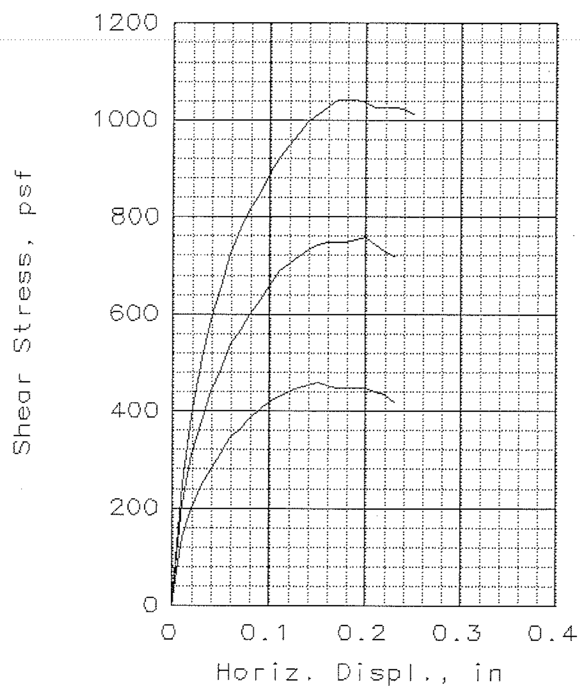
PROJ. NO.: 061420 DATE: 11/20/06

DIRECT SHEAR TEST REPORT

MATERIALS TESTING CONSULTANTS







	SAMPLE NO.:	1	2	3
INITIAL	WATER CONTENT, %	50.8	50.8	50.8
	DRY DENSITY, pcf	70.9	70.9	70.9
	SATURATION, %	99.6	99.6	99.6
	VOID RATIO	1.378	1.378	1.378
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.11	1.11	1.11
AT TEST	WATER CONTENT, %	41.3	40.2	39.3
	DRY DENSITY, pcf	77.0	78.6	79.2
	SATURATION, %	93.9	94.9	94.1
	VOID RATIO	1.188	1.144	1.127
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.02	1.00	0.99
	NORMAL STRESS, psf	600	1100	1600
	FAILURE STRESS, psf	459	758	1042
	DISPLACEMENT, in	0.15	0.20	0.17
	ULTIMATE STRESS, psf	459	758	1042
	DISPLACEMENT, in	0.15	0.20	0.19
	Strain rate, %/min	0.10	0.10	0.10

SAMPLE TYPE: 1 Gallon Pail
DESCRIPTION: Silt

SPECIFIC GRAVITY= 2.7
REMARKS: MTC Sample No. 83237

Fig. No.: ______

CLIENT: BBL

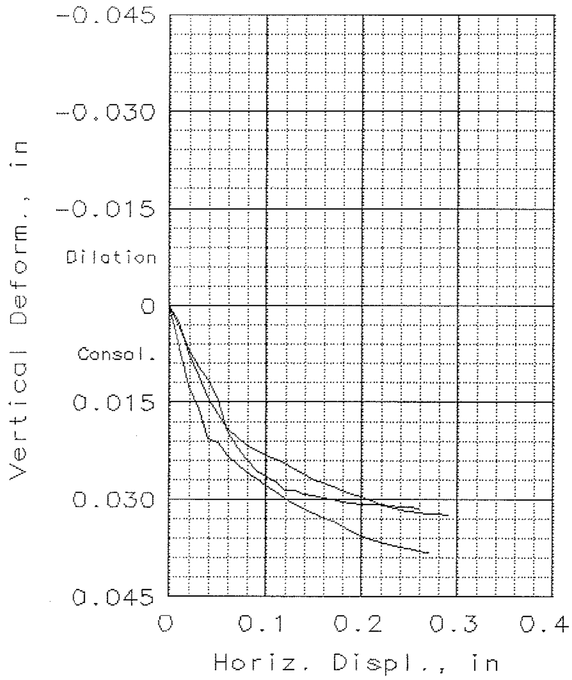
PROJECT: Bay Harbor

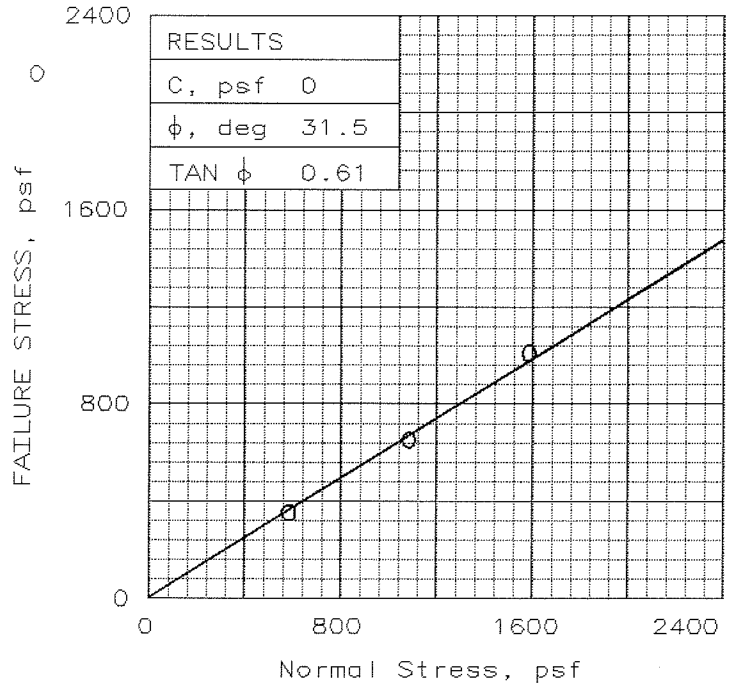
SAMPLE LOCATION: VHARBOR-15

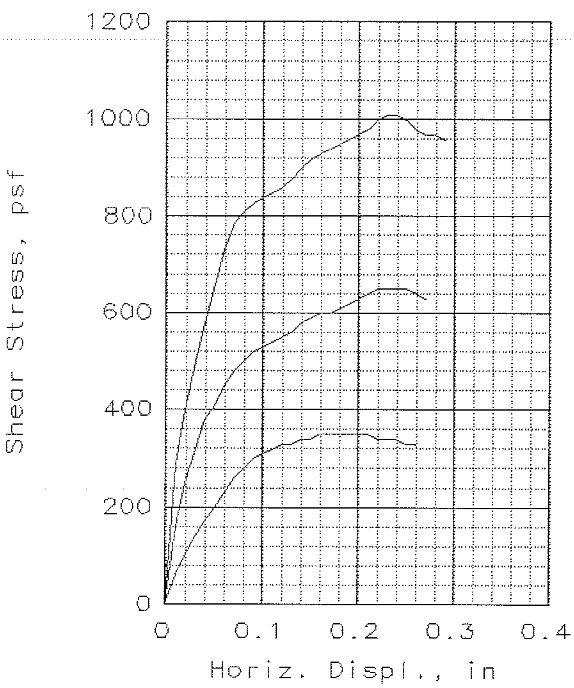
PROJ. NO.: 061420 DATE: 11/20/06

DIRECT SHEAR TEST REPORT

MATERIALS TESTING CONSULTANTS







	SAMPLE NO.:	1	2	3
INITIAL	WATER CONTENT, %	90.3	90.3	90.3
	DRY DENSITY, pcf	48.9	48.9	48.9
	SATURATION, %	99.5	99.5	99.5
	VOID RATIO	2.449	2.449	2.449
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	1.11	1.11	1.11
AT TEST	WATER CONTENT, %	70.6	66.4	63.1
	DRY DENSITY, pcf	55.4	57.4	58.4
	SATURATION, %	93.3	92.6	90.4
	VOID RATIO	2.044	1.935	1.886
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.98	0.94	0.93
	NORMAL STRESS, psf	600	1100	1600
	FAILURE STRESS, psf	349	648	1007
	DISPLACEMENT, in	0.16	0.22	0.23
	ULTIMATE STRESS, psf	349	648	1007
	DISPLACEMENT, in	0.20	0.25	0.24
	Strain rate, %/min	0.10	0.10	0.10

SAMPLE TYPE: 1 Gallon Pail

DESCRIPTION: Silt

SPECIFIC GRAVITY= 2.7

REMARKS: MTC Sample No. 83238

Fig. No.: ______

CLIENT: BBL

PROJECT: Bay Harbor

SAMPLE LOCATION: VHARBOR-17

PROJ. NO.: 061420 DATE: 11/27/06

DIRECT SHEAR TEST REPORT

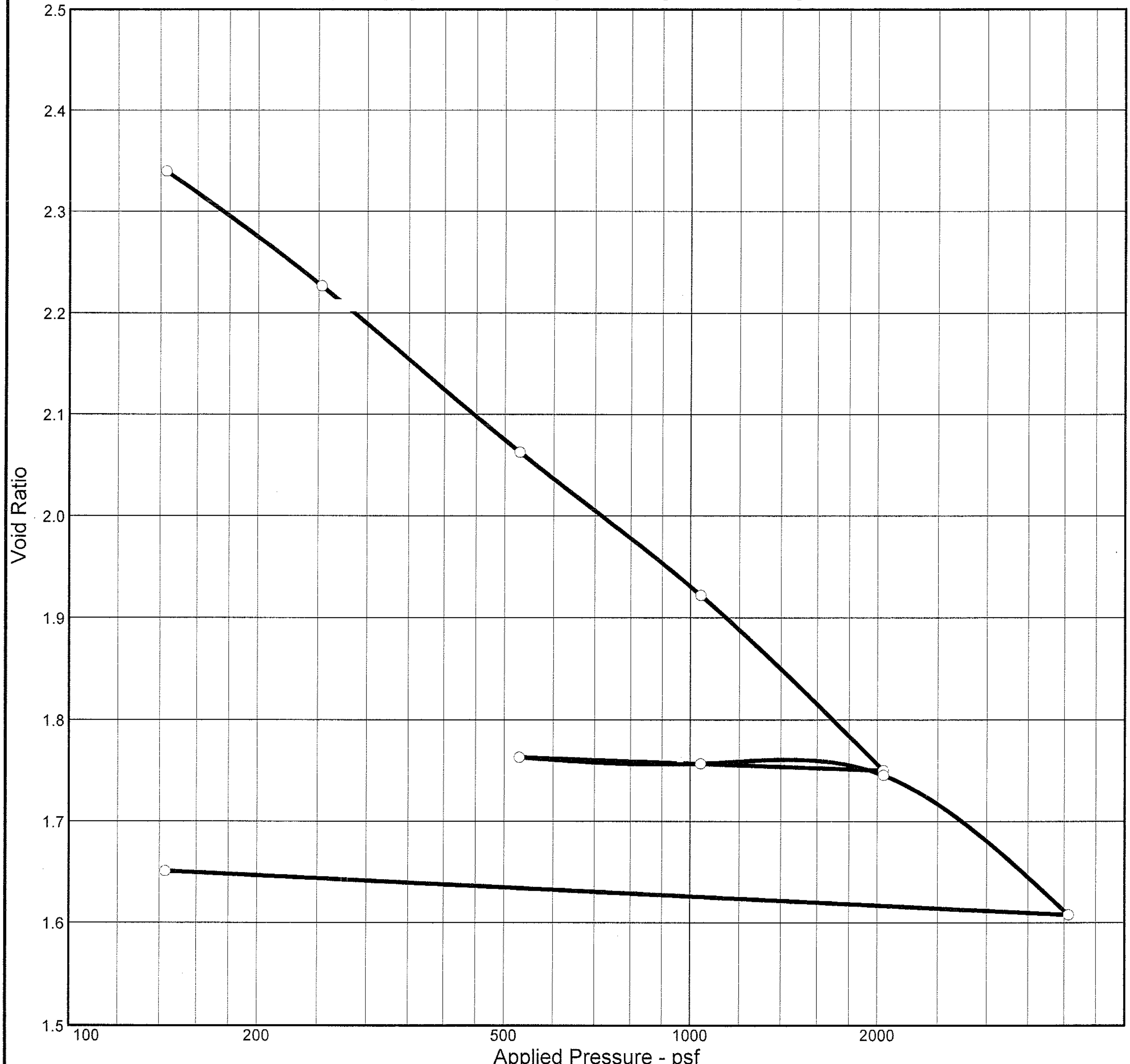
MATERIALS TESTING CONSULTANTS

Attachment E

Consolidation and Bulk Density Test Results

BBL®
an ARCADIS company

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Swell Press. (psf)	Swell %	e_o
Sat.	Moist.											
99.6 %	107.3 %	42.7			2.70		653	0.47	0.03			2.910

MATERIAL DESCRIPTION	USCS	AASHTO
1 Gallon pail CKD Sediment		

Project No. 061420 **Client:** BBL, Inc.

Project: Bay Harbor

Location: VHARBOR-14

Remarks:

CONSOLIDATION TEST REPORT

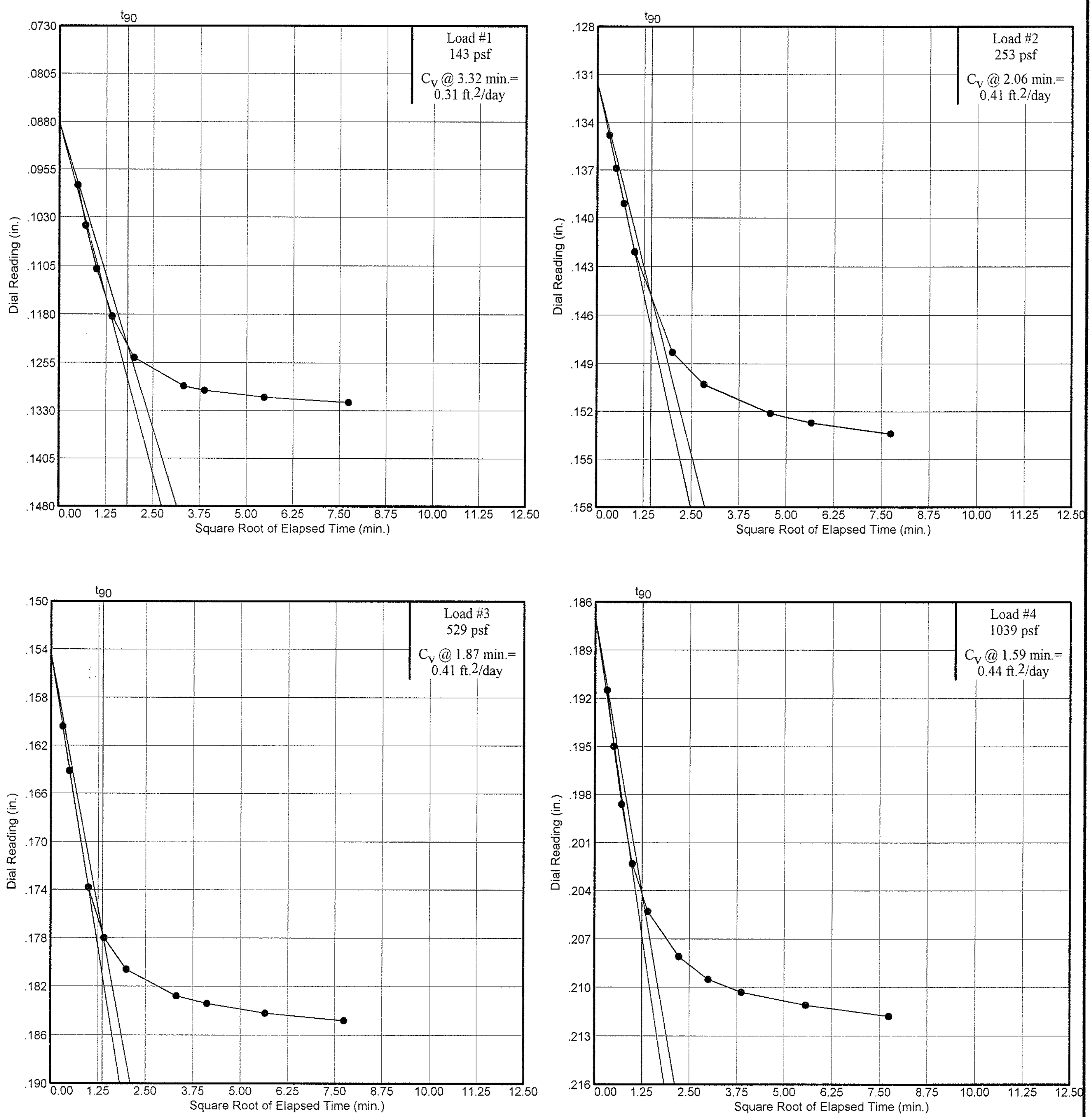
MATERIALS TESTING CONSULTANTS, INC.

Plate

Dial Reading vs. Time

Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-14



Dial Reading vs. Time

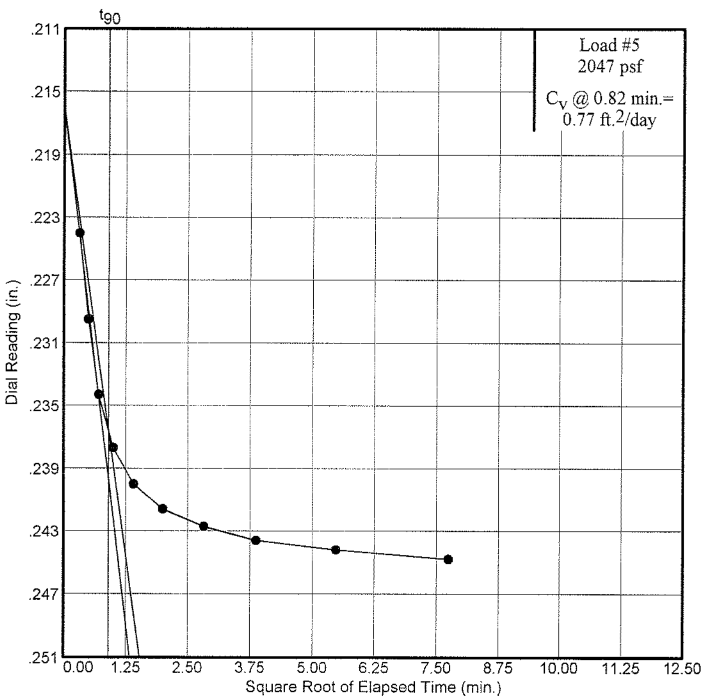
MATERIALS TESTING CONSULTANTS, INC.

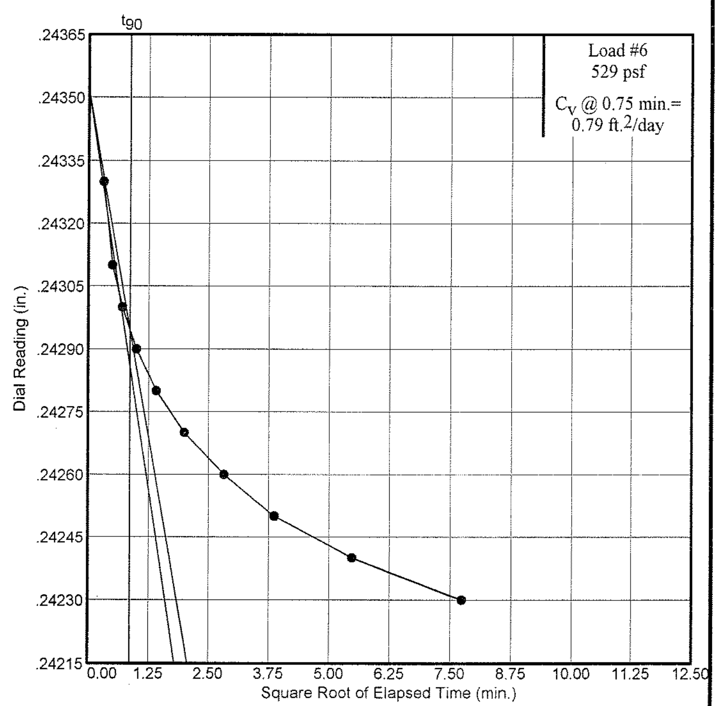
Plate

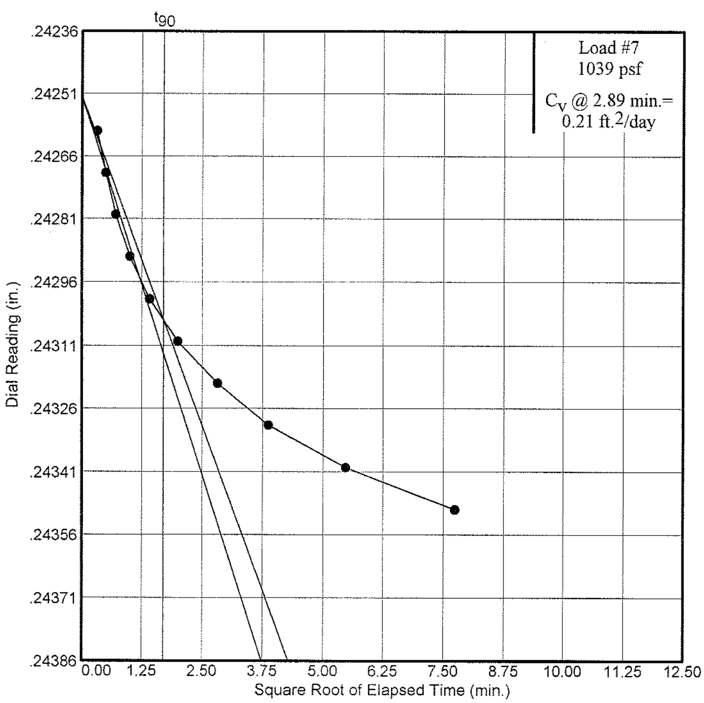
Dial Reading vs. Time

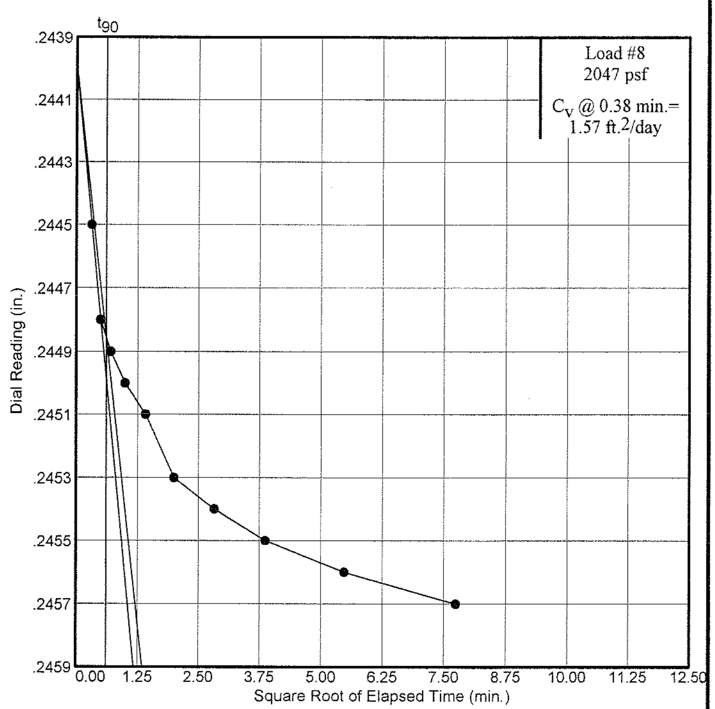
Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-14









Dial Reading vs. Time

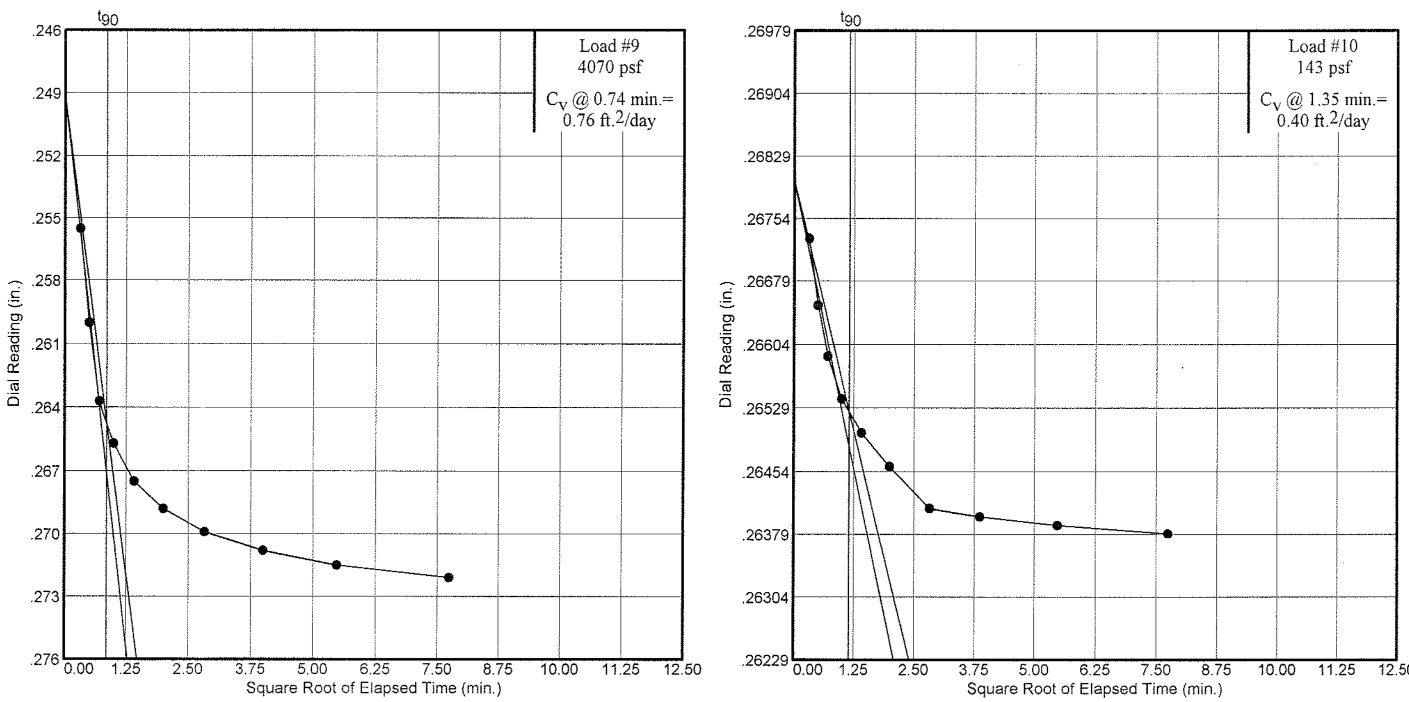
MATERIALS TESTING CONSULTANTS, INC.

Plate

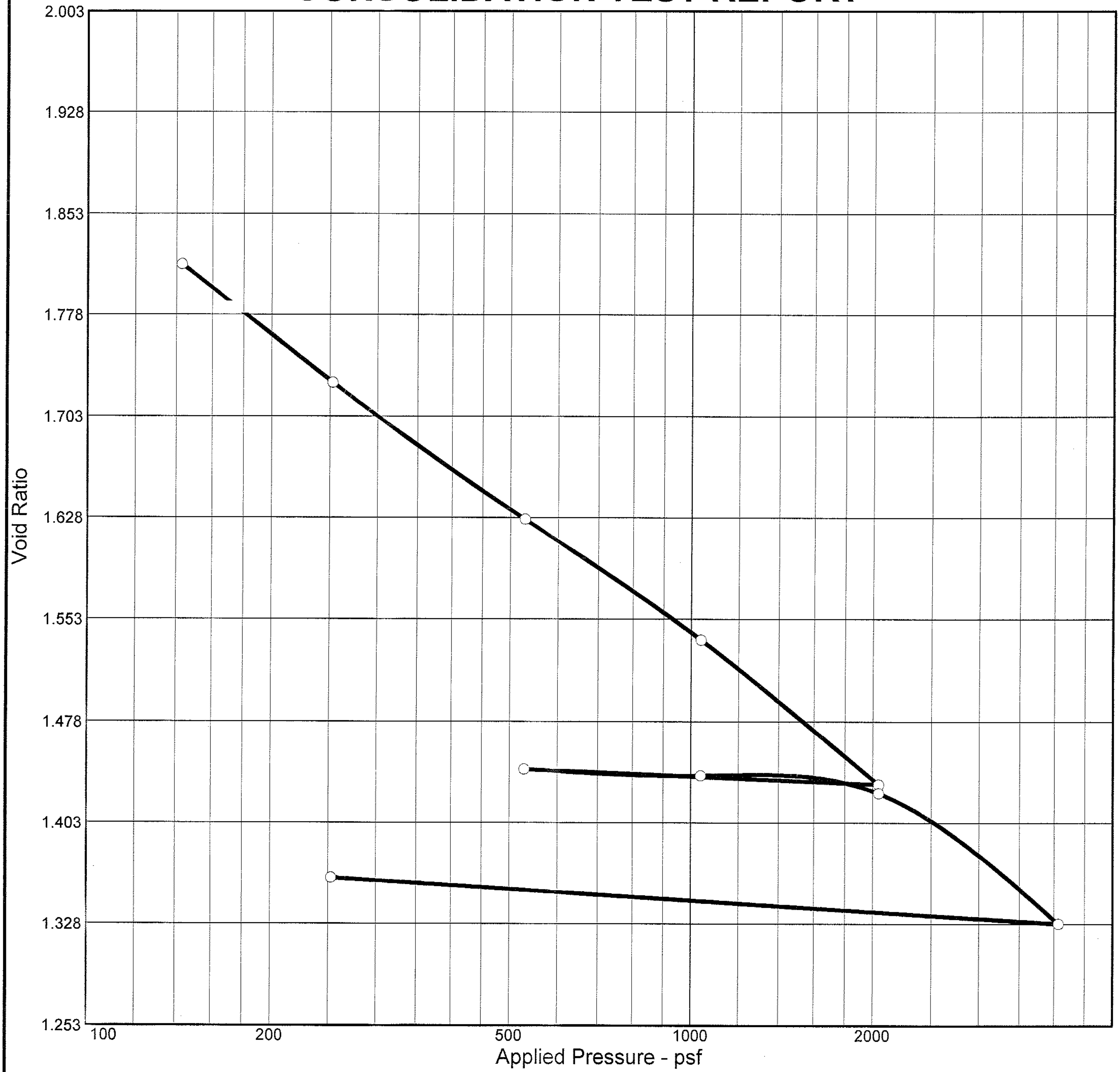
Dial Reading vs. Time

Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-14



CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Swell Press. (psf)	Swell %	e_o
Sat.	Moist.											
99.9 %	82.9 %	51.8			2.72		958	0.34	0.03			2.255

MATERIAL DESCRIPTION	USCS	AASHTO
1 Gallon pail CKD Sediment		

Project No. 061420 **Client:** BBL, Inc.

Project: Bay Harbor

Location: VHARBOR-15

Remarks:

CONSOLIDATION TEST REPORT

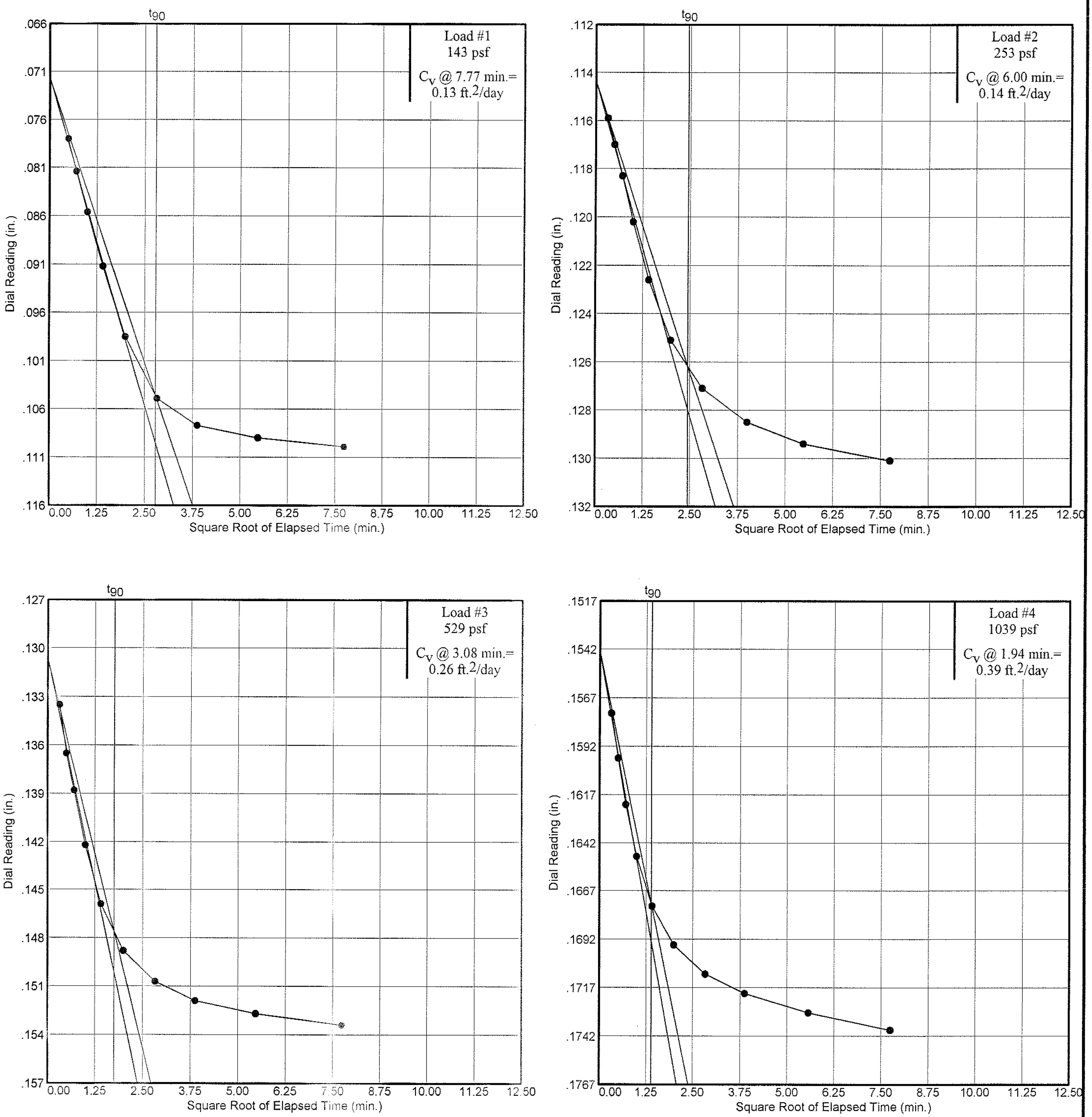
MATERIALS TESTING CONSULTANTS, INC.

Plate

Dial Reading vs. Time

Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-15



Dial Reading vs. Time

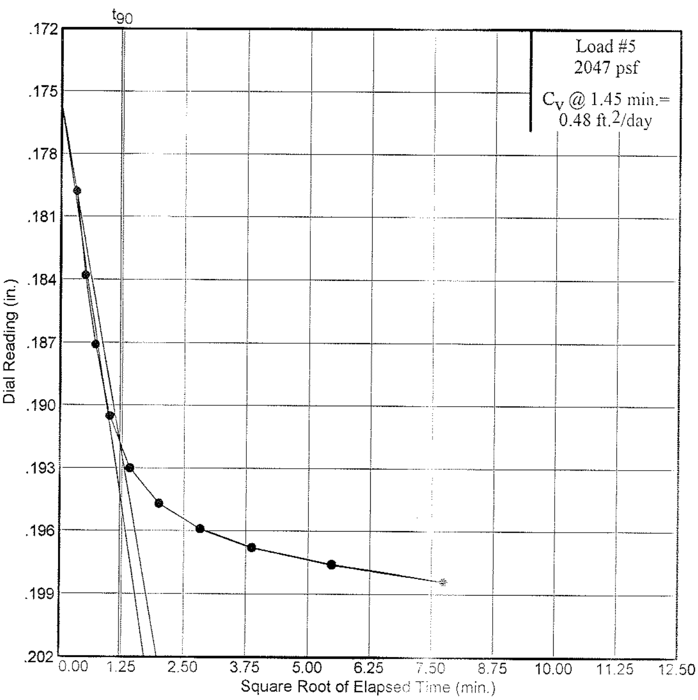
MATERIALS TESTING CONSULTANTS, INC.

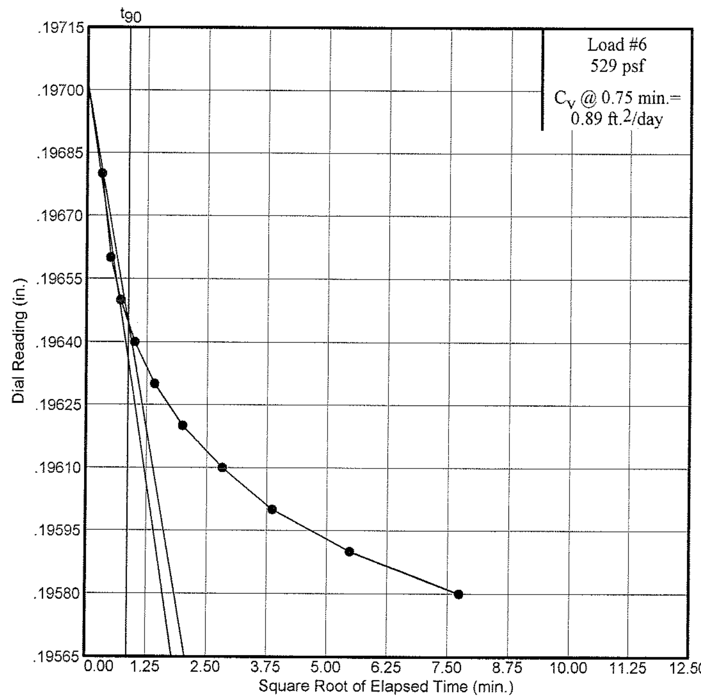
Plate

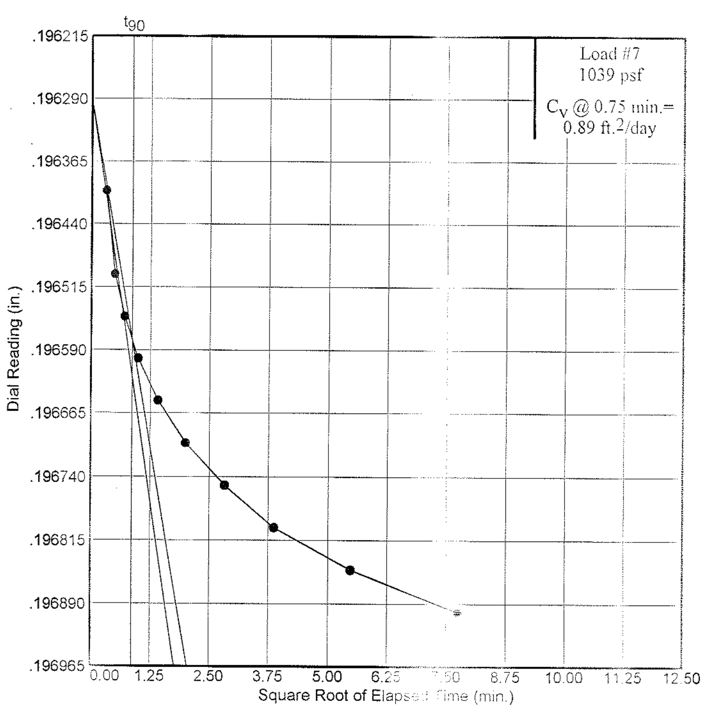
Dial Reading vs. Time

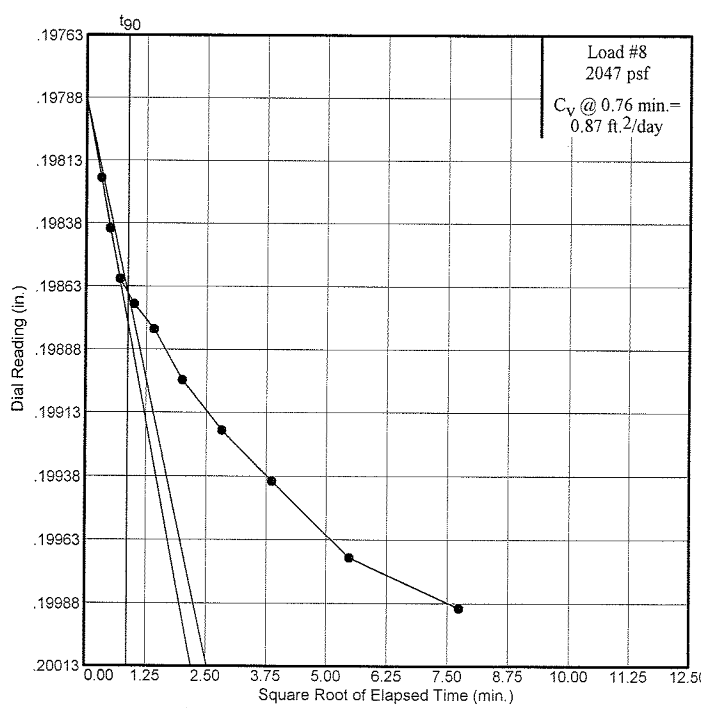
Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-15









Dial Reading vs. Time

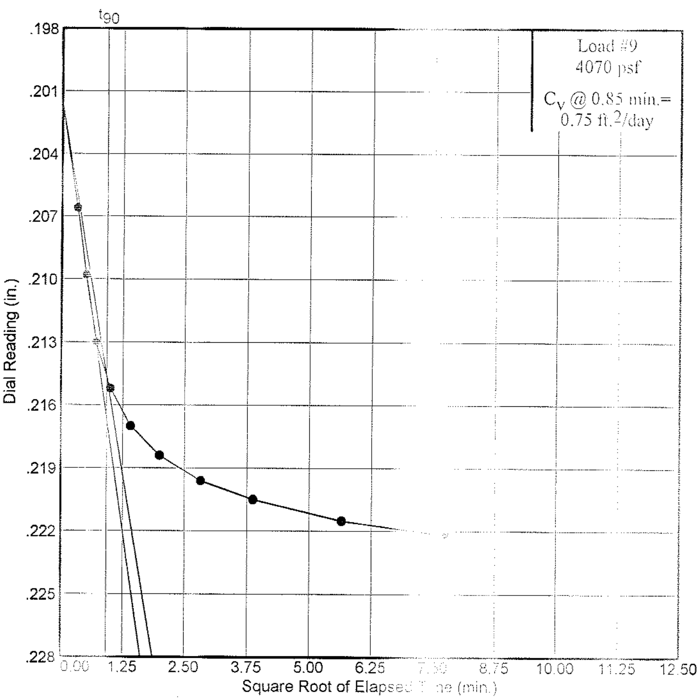
MATERIALS TESTING CONSULTANTS, INC.

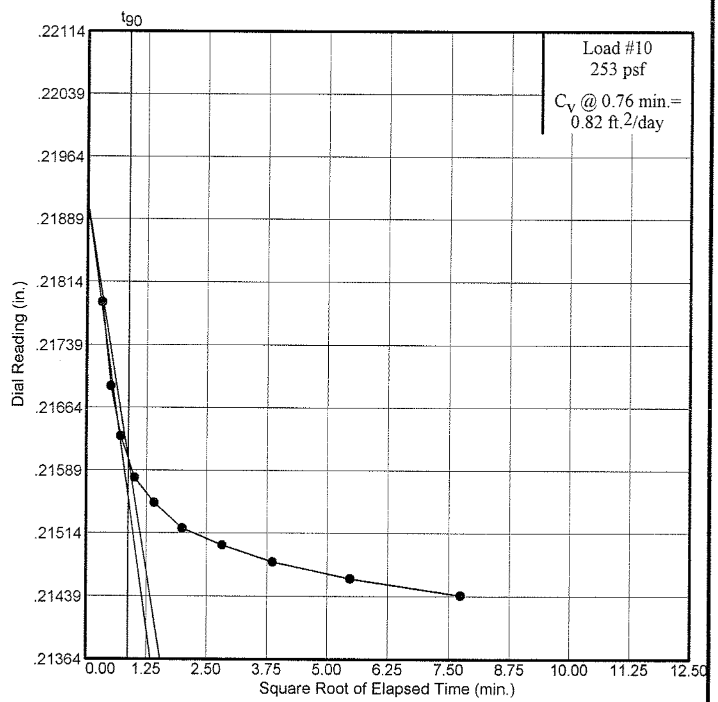
Plate

Dial Reading vs. Time

Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-15



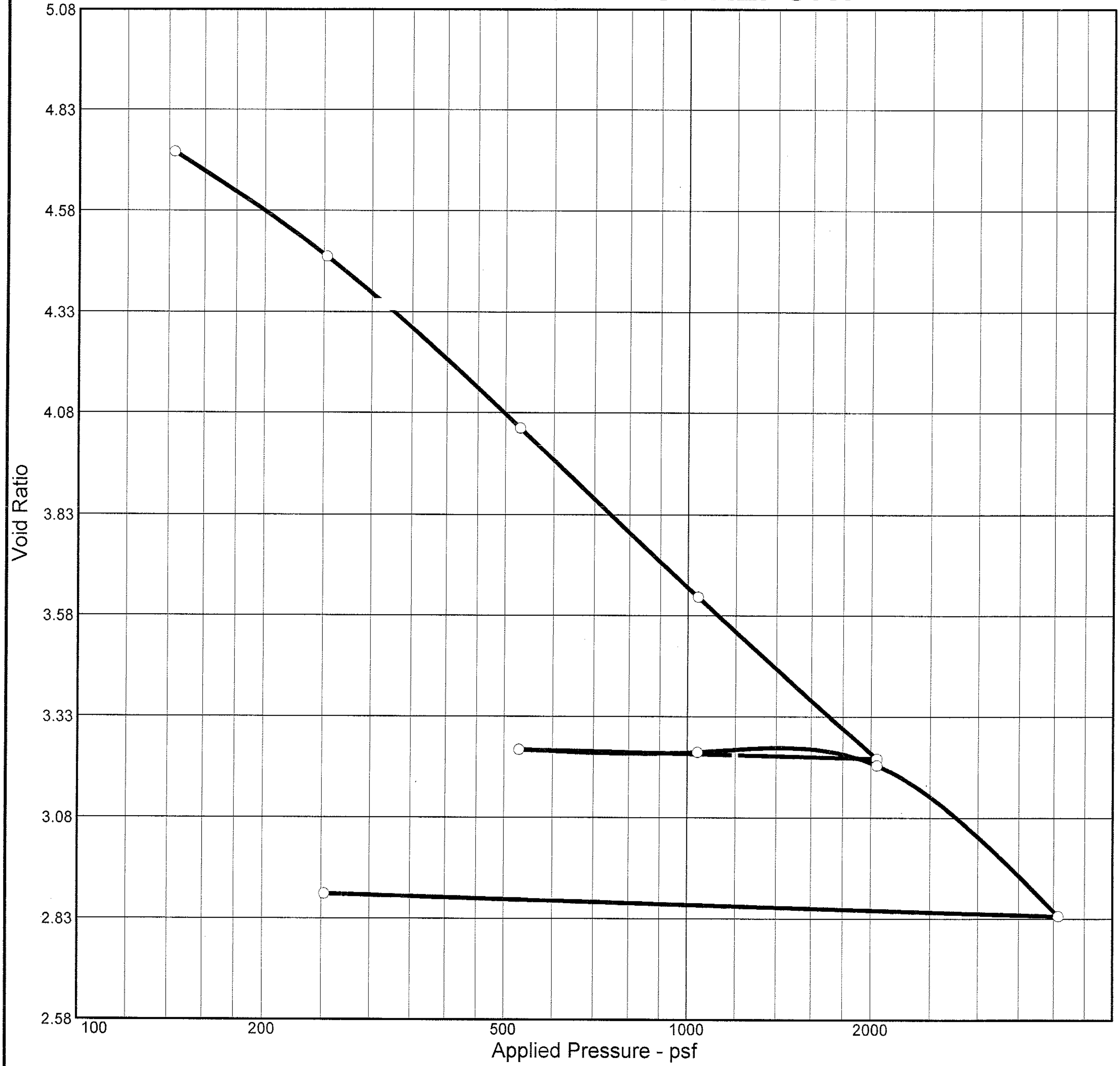


Dial Reading vs. Time

MATERIALS TESTING CONSULTANTS, INC.

Plate

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Swell Press. (psf)	Swell %	e_o
Sat.	Moist.											
100.1 %	206.6 %	25.7			2.7		207	1.30	0.05			5.571

MATERIAL DESCRIPTION	USCS	AASHTO
1 Gallon pail CKD Sediment		

Project No. 061420 **Client:** BBL, Inc.

Project: Bay Harbor

Location: VHARBOR-17

CONSOLIDATION TEST REPORT

MATERIALS TESTING CONSULTANTS, INC.

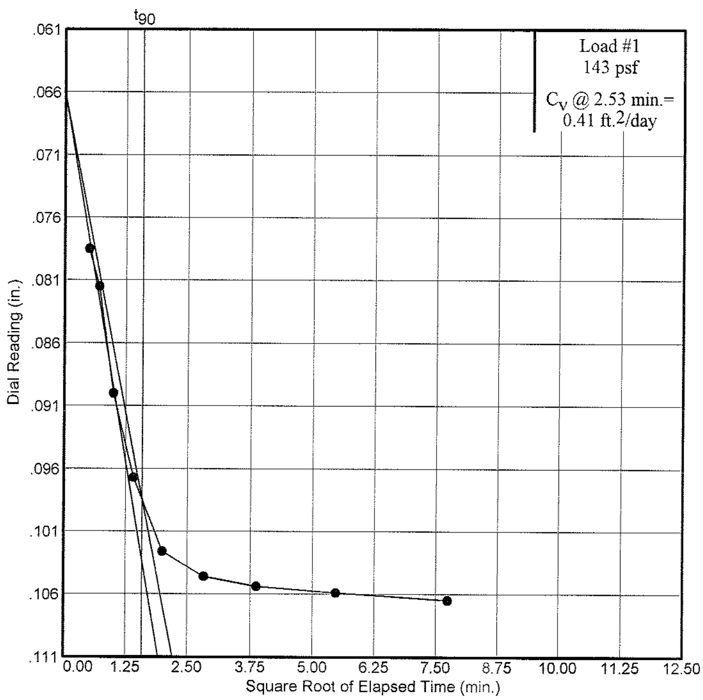
Remarks:

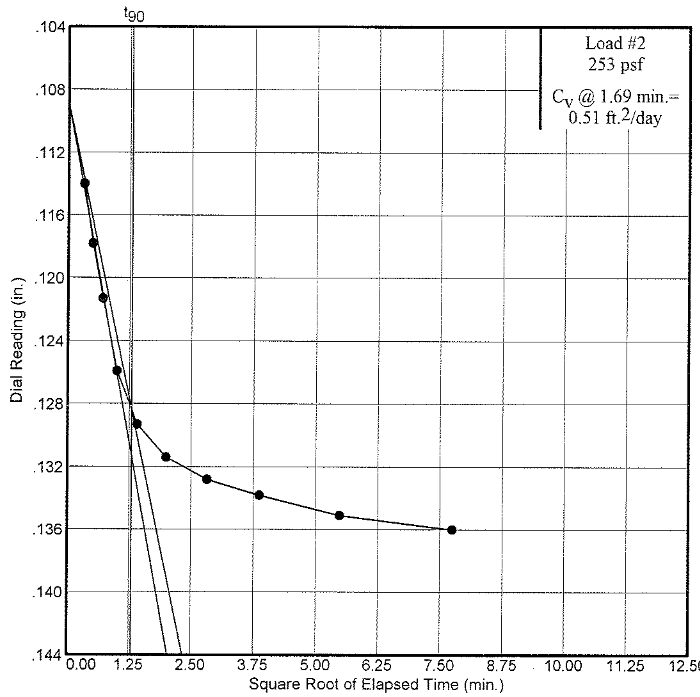
Plate

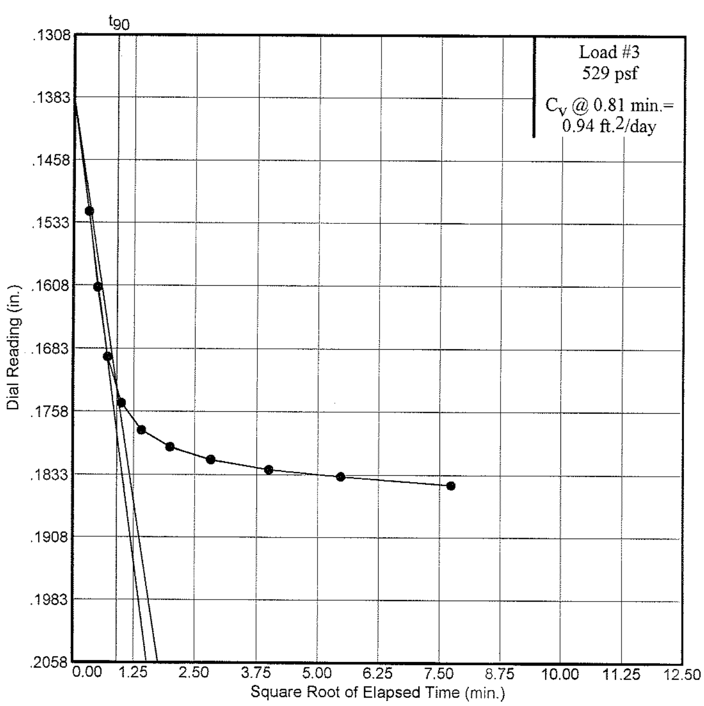
Dial Reading vs. Time

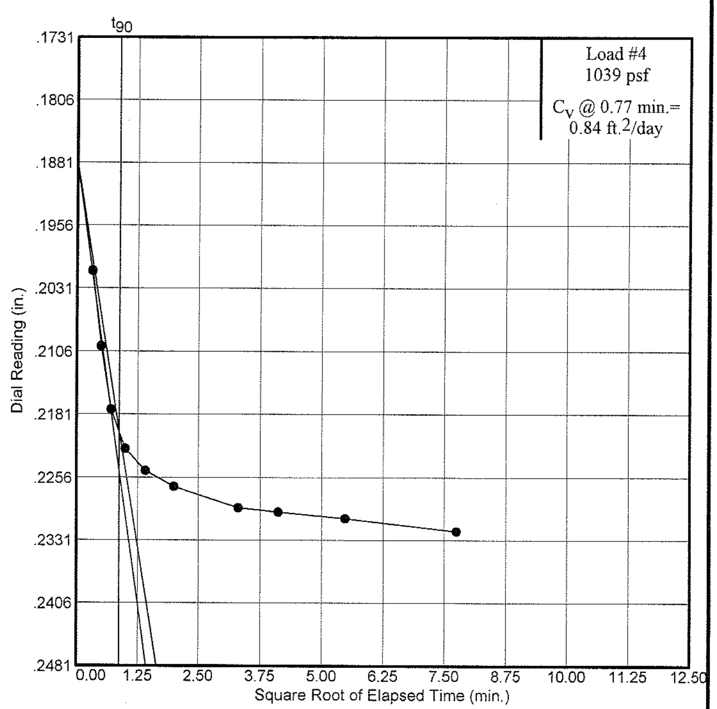
Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-17









Dial Reading vs. Time

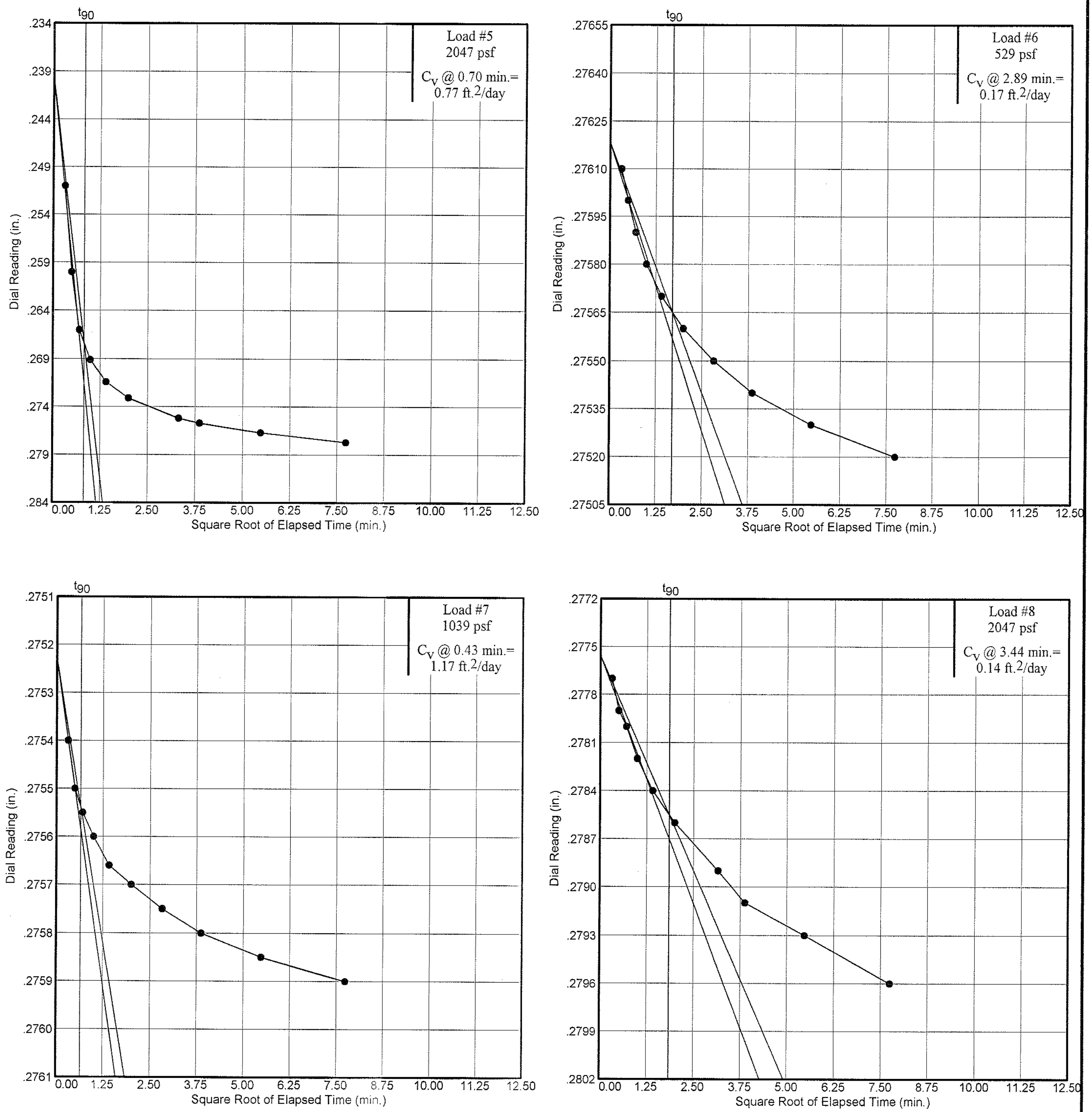
MATERIALS TESTING CONSULTANTS, INC.

Plate

Dial Reading vs. Time

Project No.: 061420
Project: Bay Harbor

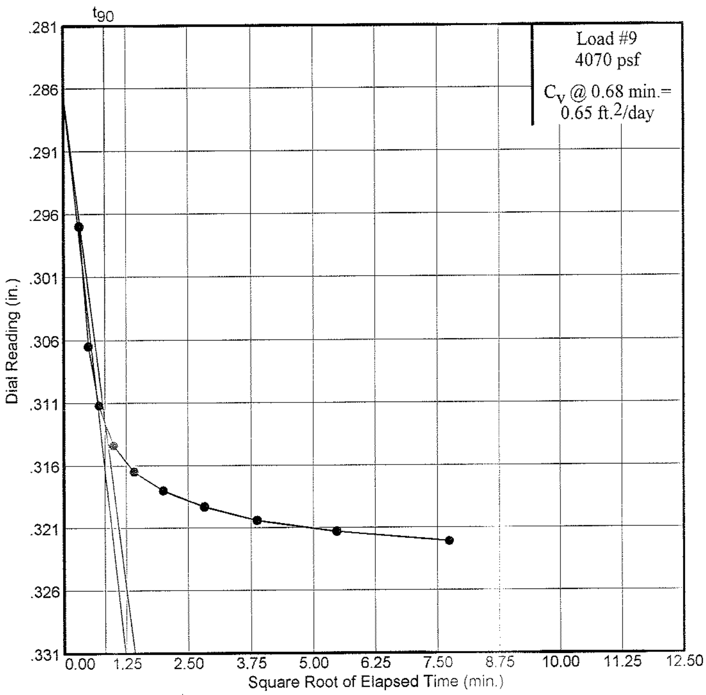
Location: VHARBOR-17

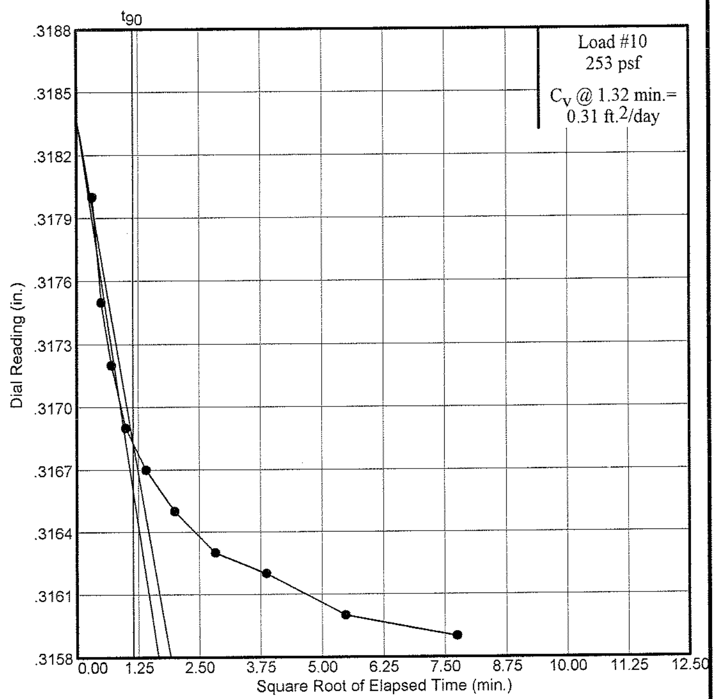


Dial Reading vs. Time

Project No.: 061420
Project: Bay Harbor

Location: VHARBOR-17





Dial Reading vs. Time

MATERIALS TESTING CONSULTANTS, INC.

Plate

ARCADIS BBL

Appendix D

Armor Design for Erosive Propeller Action

Armor Design for Southwest Corner Cover

Objective

Evaluate the armoring requirements for submerged cover to be placed in the southwest corner at Village Harbor. Since the harbor is somewhat protected from significant wave action and currents, the most critical erosive forces likely to be present are from recreational watercraft operating in the harbor. These calculations will be performed in accordance with "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments: Appendix A: Armor Layer Design," (Maynord, U.S. Army Waterways Experiment Station, Vicksburg, Mississippi) prepared for the U.S. EPA and the Great Lakes National Program Office, Assessment and Remediation of Contaminated Sediment Program, Chicago, Illinois.

Design Assumptions and Conditions

The following assumptions and conditions apply to these calculations:

- The largest watercraft assumed to use the harbor on a regular basis is 300 HP recreational craft with a maximum draft of approximately 3.5 feet (twin propeller diameter of 1.44 feet, centerline of shaft 2 feet below water level).
- Maximum throttle in the harbor is no more than about 25%.
- Water depth in the harbor will be about 10 feet following placement of the cover. Dockside areas may me as shallow as 5 feet.

Methodology

Use equations developed by Blaauw and van de Kaa (1978) for analysis of riprap size based on maximum bottom velocities in the propeller wash of a maneuvering watercraft, as follows

$$V_{b\ (\max)} = C_1\, U_o D_p / H_p$$

Where: C_1 = 0.22 for non-ducted propeller

U_o = jet velocity exiting propeller

D_p = propeller diameter

H_p = distance from propeller shaft to channel bottom

Then, the jet velocity exiting the propeller is:

$$U_o = C_2\, \{P_d / D_p^2\}^{1/3}$$

Where: U_o = jet velocity exiting propeller in ft/sec

C_2 = 9.72 for non-ducted propellers

P_d = applied engine power/propeller in Hp

D_p = propeller diameter in feet

The equation for rock size is then:

$$V_{b\,(max)} = C_3 * (g * A * D_{50})^{1/2}$$

Where: $V_{b\,(max)}$ = maximum bottom velocity

C_3 = coefficient = 0.60 for harbor areas (Maynord, 1984)

D_{50} = riprap size of which 50 percent is finer by weight

$A = (a_s - a_w) / a_w = (165\ lbs/ft^3 - 62.4\ lbs/ft^3) / 62.4\ lbs/ft^3 = 1.64$

Where a_w = unit weight of water (62.4 lbs/ft^3)

a_s = unit weight of stone (165 lbs/ft^3 typ.)

g = gravitation constant = 32.2 ft/sec^2

Calculations

For water depth varying from 5 to 10 feet, the maximum jet velocity for the watercraft would be 150 hp per propeller, so the applied power at 25% of throttle would be:

$$P_d = 0.25\ (150\ hp) = 37.5\ hp$$

Therefore, the jet velocity exiting the propeller is:

$$U_o = C_2\ \{P_d / D_p^2\}^{1/3}$$
$$= 9.72\ \{37.5 / 1.44^2\}^{1/3}$$
$$= 25.5\ ft/sec$$

Then, for a depth of 5 feet, H_p = 3 feet, and V_b can be solved as follows:

$$V_{b\ (max)} = C_1\ U_o D_p / H_p$$
$$= \{(0.22)\ (25.5\ ft/sec)\ (1.44\ ft)\} / 3\ ft$$
$$= 2.7\ ft/sec$$

For a depth of 10 feet, H_p = 8 feet, and V_b = 1.0 ft/sec.

Riprap size can be solved as follows for depth = 5 feet:

$$V_{b\,(max)} = C_3 * (g * A * D_{50})^{1/2}$$
$$2.7\ ft/sec = 0.60\ (32.2\ ft/sec^2 * 1.64 * D_{50})^{1/2}$$
$$(4.5\ ft/sec)^2 = 52.81\ ft/sec^2 * D_{50}$$
$$D_{50} = (20.25\ ft2/sec2)\ / 52.81\ ft/sec^2$$
$$= 0.38\ ft$$

Riprap size can be solved as follows for depth = 10 feet:

$$V_{b\,(max)} = C_3 * (g * A * D_{50})^{1/2}$$

$$1.0\,ft/sec = 0.60\,(32.2\,ft/sec^2 * 1.64 * D_{50})^{1/2}$$

$$(1.7\,ft/sec)^2 = 52.81\,ft/sec^2 * D_{50}$$

$$D_{50} = (2.78\,ft2\,/sec2)\ /\ 52.81\,ft/sec^2$$

$$= 0.053\,ft$$

For the shallow depth of 5 feet, Table A1 of EM1110-2-1601 (US Army Corps of Engineers, 1994) provides D_{50} (min.) equal to 0.38 feet with a minimum layer thickness of nine inches. For the 10-foot depth and D_{50} = 0.053 feet, the rock size is equivalent to a large gravel.

Conclusions

The upper gravel layer to be used for the cap should be specified to be a large gravel gradation, and a layer thickness of at least one foot should be sufficient to protect against erosion from propeller watercraft in the main harbor traffic areas. However, if watercraft are operated in more shallow areas (such as a shallow dockside environment), any cover placed in those areas should be protected with a riprap sized such that 50% if the stone is smaller than 0.38 feet and 50% is larger than this size.

References

Blaauw, H.G., van der Knaap, F.C.M., 1978, "Erosion of Bottom and Banks Caused by the Screw Race of Maneuvering Ships," Publication No. 202, Delft Hydraulic Laboratory, Delft, The Netherlands, presented at the Seventh International Harbor Congress, Antwerp, May 22-26.

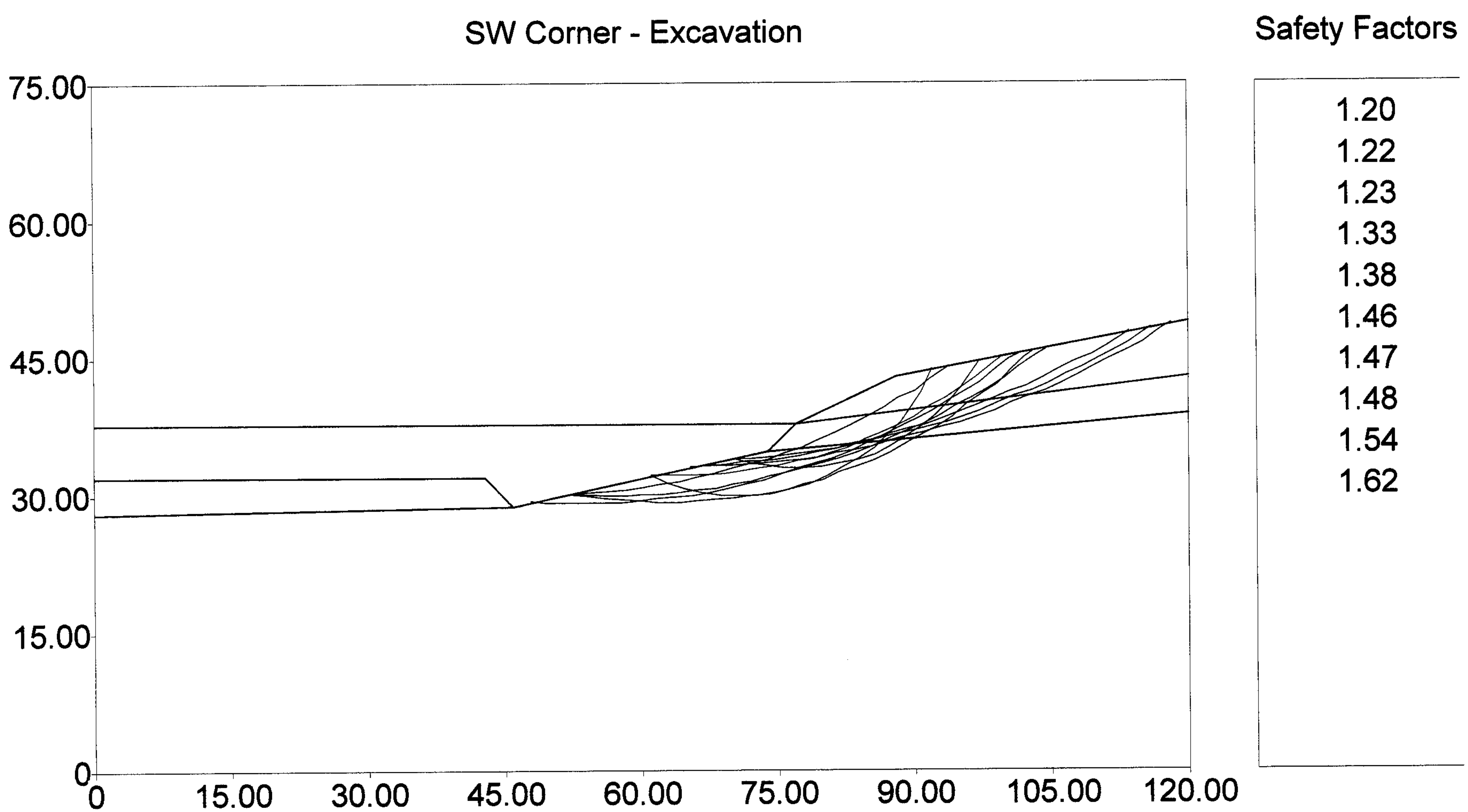
Headquarters, US Army Corps of Engineers. 1994. "Hydraulic Design of Flood Control Channels," EM 1110-2-1601, US Government Printing Office, Washington, DC.

Maynord, S.T., 1984. "Riprap Protection on Navigation Waterways," U.S. Army Engineer Waterways Experiment Station, Technical Report HL-84-3.

Maynord, S., "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments: Appendix A: Armor Layer Design,"U.S. Army Waterways Experiment Station, Vicksburg, Mississippi.

Appendix E

Excavation Slope Stability Analysis



3' Excavation - No Load

```
PROFIL
SW Corner - Excavation
8 6
0.00 32.00 43.00 32.00 2
43.00 32.00 46.00 29.00 2
46.00 29.00 74.00 35.00 3
74.00 35.00 77.00 38.00 1
77.00 38.00 88.00 43.00 1
88.00 43.00 120.00 49.00 1
0.00 28.00 46.00 29.00 3
74.00 35.00 120.00 39.00 3
SOIL
3
105.00 115.00 0.00 22.00 0.00 0.00 2
75.00 80.00 50.00 15.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 43.00
CIRCLE
10 10 30.00 70.00 90.00 120.00 20.00 2.00 5.00 -80.00
```

** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION   SW Corner - Excavation

BOUNDARY COORDINATES

6 Top   Boundaries
8 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	2
2	43.00	32.00	46.00	29.00	2
3	46.00	29.00	74.00	35.00	3
4	74.00	35.00	77.00	38.00	1
5	77.00	38.00	88.00	43.00	1
6	88.00	43.00	120.00	49.00	1
7	0.00	28.00	46.00	29.00	3
8	74.00	35.00	120.00	39.00	3

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	22.0	0.00	0.0	2
2	75.0	80.0	50.0	15.0	0.00	0.0	1
3	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	43.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 30.00 ft. and X = 70.00 ft.

Each Surface Terminates Between X = 90.00 ft. and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 20.00 ft.

2.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -80.0 And 5.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 22 Coordinate Points

Point X-Surf Y-Surf

No.	(ft)	(ft)
1	61.11	32.24
2	63.11	32.18
3	65.11	32.19
4	67.11	32.27
5	69.10	32.42
6	71.09	32.65
7	73.07	32.94
8	75.03	33.31
9	76.99	33.74
10	78.92	34.25
11	80.84	34.82
12	82.73	35.47
13	84.60	36.18
14	86.44	36.96
15	88.26	37.80
16	90.04	38.71
17	91.79	39.68
18	93.50	40.71
19	95.18	41.80
20	96.81	42.95
21	98.40	44.17
22	99.65	45.18

*** 1.200 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	30.33
2	54.22	30.42
3	56.22	30.56
4	58.21	30.75
5	60.19	30.99
6	62.17	31.28
7	64.14	31.62
8	66.10	32.02
9	68.05	32.46
10	69.99	32.96
11	71.91	33.51
12	73.82	34.10
13	75.72	34.75
14	77.59	35.44
15	79.45	36.18
16	81.29	36.97
17	83.10	37.81
18	84.90	38.69
19	86.67	39.62
20	88.41	40.60
21	90.13	41.62
22	91.83	42.68
23	93.49	43.79
24	93.96	44.12

*** 1.218 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	34.14
2	71.93	33.61
3	73.90	33.25
4	75.89	33.07
5	77.89	33.05
6	79.88	33.21
7	81.85	33.54
8	83.79	34.03
9	85.68	34.70
10	87.50	35.52
11	89.24	36.50
12	90.90	37.62
13	92.45	38.89
14	93.88	40.28
15	95.19	41.79
16	96.36	43.41
17	97.15	44.71

*** 1.234 ***

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	33.19
2	67.55	33.32
3	69.54	33.49
4	71.53	33.70
5	73.52	33.95
6	75.50	34.23
7	77.47	34.55
8	79.44	34.91
9	81.40	35.30
10	83.35	35.73
11	85.30	36.20
12	87.23	36.70
13	89.16	37.24
14	91.08	37.82
15	92.98	38.43
16	94.87	39.08
17	96.75	39.76
18	98.62	40.48
19	100.47	41.23
20	102.31	42.02
21	104.13	42.84
22	105.94	43.70
23	107.73	44.59
24	109.50	45.52
25	111.26	46.47

26	113.00	47.46
27	113.55	47.79

*** 1.333 ***

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	34.14
2	72.00	34.25
3	73.99	34.39
4	75.98	34.58
5	77.97	34.81
6	79.95	35.08
7	81.93	35.39
8	83.90	35.74
9	85.86	36.14
10	87.81	36.57
11	89.75	37.05
12	91.68	37.57
13	93.60	38.12
14	95.51	38.72
15	97.41	39.36
16	99.29	40.04
17	101.16	40.75
18	103.01	41.51
19	104.85	42.30
20	106.66	43.13
21	108.46	44.00
22	110.25	44.91
23	112.01	45.86
24	113.75	46.84
25	115.47	47.86
26	116.16	48.28

*** 1.382 ***

Failure Surface Specified By 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	32.24
2	62.96	31.47
3	64.87	30.87
4	66.82	30.43
5	68.80	30.17
6	70.80	30.07
7	72.80	30.15
8	74.78	30.41
9	76.74	30.83
10	78.65	31.42
11	80.50	32.17

12	82.28	33.08
13	83.98	34.14
14	85.58	35.34
15	87.07	36.67
16	88.43	38.13
17	89.67	39.70
18	90.77	41.38
19	91.71	43.14
20	91.98	43.75

*** 1.455 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	33.19
2	67.56	33.25
3	69.55	33.35
4	71.55	33.49
5	73.54	33.66
6	75.53	33.87
7	77.51	34.12
8	79.49	34.41
9	81.47	34.74
10	83.43	35.10
11	85.39	35.50
12	87.34	35.94
13	89.29	36.42
14	91.22	36.93
15	93.14	37.48
16	95.05	38.06
17	96.96	38.68
18	98.84	39.34
19	100.72	40.04
20	102.58	40.77
21	104.43	41.53
22	106.26	42.33
23	108.08	43.16
24	109.88	44.03
25	111.67	44.94
26	113.43	45.87
27	115.18	46.84
28	116.91	47.85
29	118.28	48.68

*** 1.466 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	30.33

2	54.22	30.23
3	56.22	30.19
4	58.22	30.19
5	60.22	30.24
6	62.22	30.35
7	64.21	30.50
8	66.20	30.71
9	68.18	30.97
10	70.16	31.28
11	72.13	31.63
12	74.08	32.04
13	76.03	32.50
14	77.97	33.01
15	79.89	33.57
16	81.79	34.17
17	83.68	34.82
18	85.56	35.53
19	87.41	36.28
20	89.24	37.07
21	91.06	37.92
22	92.85	38.81
23	94.62	39.74
24	96.36	40.72
25	98.08	41.74
26	99.77	42.81
27	101.43	43.92
28	103.07	45.07
29	104.42	46.08

*** 1.482 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.78	29.38
2	49.77	29.27
3	51.77	29.20
4	53.77	29.19
5	55.77	29.22
6	57.77	29.31
7	59.77	29.45
8	61.76	29.64
9	63.74	29.88
10	65.72	30.17
11	67.69	30.51
12	69.66	30.89
13	71.61	31.33
14	73.55	31.82
15	75.47	32.36
16	77.38	32.95
17	79.28	33.58
18	81.16	34.26
19	83.02	34.99
20	84.87	35.77
21	86.69	36.59
22	88.49	37.46
23	90.27	38.38

24	92.02	39.34
25	93.75	40.34
26	95.46	41.39
27	97.13	42.48
28	98.78	43.61
29	100.40	44.79
30	101.33	45.50

*** 1.537 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	30.33
2	54.19	29.98
3	56.17	29.70
4	58.16	29.49
5	60.16	29.35
6	62.15	29.28
7	64.15	29.29
8	66.15	29.36
9	68.15	29.51
10	70.14	29.72
11	72.12	30.01
12	74.08	30.37
13	76.04	30.79
14	77.98	31.29
15	79.89	31.85
16	81.79	32.48
17	83.67	33.18
18	85.51	33.95
19	87.33	34.78
20	89.12	35.67
21	90.88	36.63
22	92.60	37.65
23	94.28	38.73
24	95.92	39.87
25	97.53	41.07
26	99.09	42.32
27	100.60	43.63
28	102.06	44.99
29	102.86	45.79

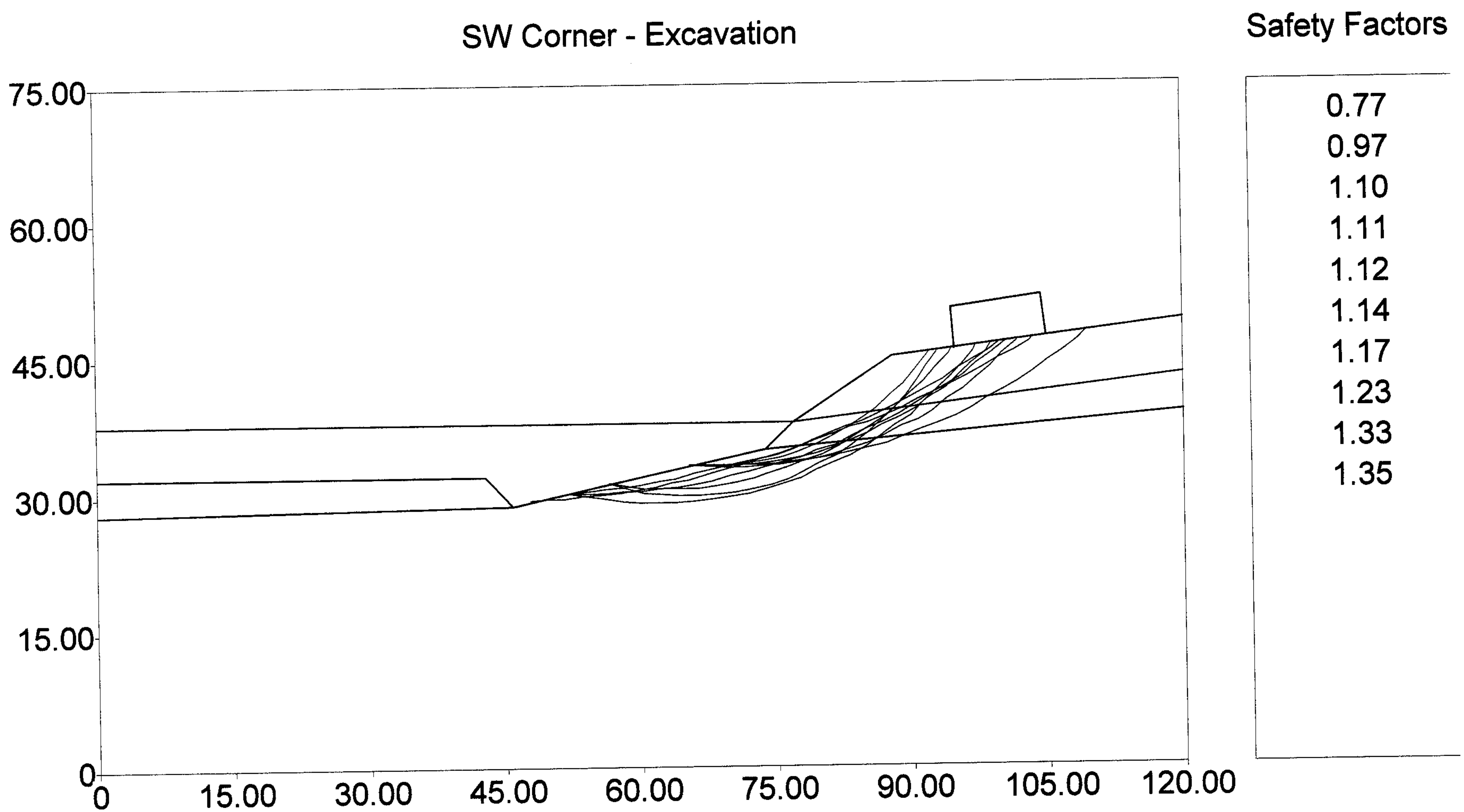
*** 1.620 ***

```
          Y           A     X     I     S           F     T

             0.00      15.00     30.00     45.00     60.00     75.00

 X     0.00 +---------+--------*+*---W----+---------+---------+
            -
```

```
             -
             -
             -
             -
       15.00 +
             -
             -
             -
             -
             -
A      30.00 +                    .
             -                  ...
             -                 ....
             -                .....
             -               ......
             -              ......*
X      45.00 +              ....*.
             -             ......9
             -             ......9
             -             .....92
             -            ......92
             -            .......2.
I      60.00 +            .......81
             -            .......81
             -            .......814
             -            .......681
             -             ......6813
             -             ......6814
S      75.00 +             ......681*
             -             .......6142*
             -            ........6312
             -            .........3712
             -            ..........31.2
             -             .........03122 *
       90.00 +             ..........331.2.
             -             ...........51122
             -              ..........74312.
             -              ...........54813
             -               ..........74081
             -                ..........74880
F     105.00 +                ...........54.8
             -                  .........754.
             -                  ..........74..
             -                    .........744
             -                      .........55
             -                         ......7
T     120.00 +                         *  W...*
```



3' Excavation - Static Load

```
PROFIL
SW Corner - Excavation
8 6
0.00 32.00 43.00 32.00 2
43.00 32.00 46.00 29.00 2
46.00 29.00 74.00 35.00 3
74.00 35.00 77.00 38.00 1
77.00 38.00 88.00 45.00 1
88.00 45.00 120.00 49.00 1
0.00 28.00 46.00 29.00 3
74.00 35.00 120.00 39.00 3
SOIL
3
105.00 115.00 0.00 22.00 0.00 0.00 2
75.00 80.00 50.00 15.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 43.00
LOADS
1
95.00 105.00 35.30 5.00
CIRCLE
10 10 30.00 70.00 90.00 120.00 20.00 2.00 5.00 -80.00
```

Profile.out

** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION SW Corner - Excavation

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	2
2	43.00	32.00	46.00	29.00	2
3	46.00	29.00	74.00	35.00	3
4	74.00	35.00	77.00	38.00	1
5	77.00	38.00	88.00	45.00	1
6	88.00	45.00	120.00	49.00	1
7	0.00	28.00	46.00	29.00	3
8	74.00	35.00	120.00	39.00	3

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	22.0	0.00	0.0	2
2	75.0	80.0	50.0	15.0	0.00	0.0	1
3	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	43.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	95.00	105.00	35.3	5.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 30.00 ft.
and X = 70.00 ft.

Each Surface Terminates Between X = 90.00 ft.
and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 20.00 ft.

2.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -80.0

And 5.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	33.19
2	67.55	33.10
3	69.55	33.14
4	71.55	33.31
5	73.52	33.62
6	75.47	34.07
7	77.39	34.64
8	79.26	35.34
9	81.08	36.17
10	82.84	37.12
11	84.54	38.18
12	86.15	39.36
13	87.69	40.64
14	89.13	42.03
15	90.48	43.50
16	91.72	45.07
17	92.02	45.50

*** 0.772 ***

Failure Surface Specified By 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	33.19
2	67.55	33.09
3	69.55	33.09
4	71.55	33.18
5	73.54	33.37
6	75.52	33.65
7	77.49	34.03
8	79.43	34.51
9	81.35	35.08
10	83.23	35.74
11	85.09	36.49
12	86.90	37.33
13	88.67	38.26
14	90.40	39.27
15	92.07	40.37

16	93.69	41.54
17	95.25	42.79
18	96.75	44.12
19	98.18	45.51
20	98.99	46.37

*** 0.974 ***

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	33.19
2	67.55	33.01
3	69.55	32.92
4	71.55	32.92
5	73.54	33.02
6	75.53	33.21
7	77.51	33.50
8	79.48	33.88
9	81.42	34.36
10	83.34	34.92
11	85.23	35.58
12	87.08	36.33
13	88.90	37.16
14	90.68	38.07
15	92.41	39.07
16	94.09	40.16
17	95.72	41.32
18	97.30	42.55
19	98.81	43.86
20	100.26	45.24
21	101.64	46.69
22	101.66	46.71

*** 1.104 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	30.33
2	54.22	30.50
3	56.21	30.71
4	58.19	30.94
5	60.17	31.22
6	62.15	31.52
7	64.12	31.87
8	66.08	32.24
9	68.04	32.65
10	69.99	33.09
11	71.93	33.57
12	73.87	34.08

13	75.79	34.63
14	77.71	35.21
15	79.61	35.82
16	81.50	36.46
17	83.39	37.14
18	85.26	37.85
19	87.11	38.59
20	88.96	39.36
21	90.79	40.17
22	92.60	41.01
23	94.40	41.88
24	96.19	42.78
25	97.96	43.71
26	99.71	44.67
27	101.45	45.67
28	103.17	46.69
29	103.59	46.95

*** 1.112 ***

Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.67	31.29
2	58.65	30.99
3	60.64	30.79
4	62.63	30.70
5	64.63	30.71
6	66.63	30.81
7	68.62	31.02
8	70.60	31.33
9	72.55	31.74
10	74.49	32.25
11	76.39	32.85
12	78.27	33.55
13	80.10	34.34
14	81.90	35.23
15	83.64	36.20
16	85.34	37.26
17	86.98	38.41
18	88.56	39.64
19	90.07	40.94
20	91.52	42.32
21	92.90	43.78
22	94.20	45.30
23	94.60	45.83

*** 1.120 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	47.78	29.38
2	49.78	29.48
3	51.77	29.62
4	53.76	29.80
5	55.75	30.02
6	57.73	30.27
7	59.71	30.57
8	61.68	30.91
9	63.65	31.29
10	65.60	31.70
11	67.55	32.16
12	69.49	32.65
13	71.42	33.18
14	73.33	33.75
15	75.24	34.36
16	77.13	35.01
17	79.01	35.69
18	80.88	36.41
19	82.73	37.17
20	84.56	37.97
21	86.38	38.80
22	88.18	39.67
23	89.97	40.57
24	91.73	41.51
25	93.48	42.49
26	95.20	43.50
27	96.91	44.54
28	98.59	45.62
29	99.89	46.49

*** 1.141 ***

Failure Surface Specified By 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	30.33
2	54.22	30.30
3	56.22	30.32
4	58.22	30.39
5	60.22	30.52
6	62.21	30.70
7	64.19	30.94
8	66.17	31.23
9	68.14	31.57
10	70.10	31.97
11	72.05	32.42
12	73.99	32.92
13	75.91	33.48
14	77.81	34.09
15	79.70	34.75
16	81.57	35.46
17	83.42	36.22
18	85.25	37.03
19	87.06	37.89
20	88.84	38.80
21	90.59	39.76

22	92.32	40.76
23	94.02	41.81
24	95.70	42.91
25	97.34	44.05
26	98.95	45.24
27	100.52	46.47
28	100.66	46.58

*** 1.168 ***

Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.67	31.29
2	58.60	30.76
3	60.55	30.35
4	62.53	30.07
5	64.53	29.92
6	66.53	29.90
7	68.53	30.00
8	70.51	30.24
9	72.48	30.60
10	74.42	31.08
11	76.32	31.70
12	78.18	32.43
13	80.00	33.28
14	81.75	34.24
15	83.43	35.32
16	85.05	36.50
17	86.58	37.78
18	88.03	39.16
19	89.39	40.63
20	90.65	42.18
21	91.81	43.81
22	92.86	45.51
23	92.92	45.61

*** 1.226 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	33.19
2	67.55	33.09
3	69.55	33.05
4	71.55	33.08
5	73.55	33.17
6	75.54	33.32
7	77.53	33.55
8	79.51	33.83
9	81.48	34.18

10	83.44	34.60
11	85.38	35.08
12	87.30	35.62
13	89.21	36.22
14	91.10	36.89
15	92.96	37.61
16	94.80	38.40
17	96.61	39.24
18	98.40	40.15
19	100.15	41.11
20	101.87	42.13
21	103.56	43.21
22	105.21	44.33
23	106.82	45.52
24	108.39	46.75
25	109.51	47.69

*** 1.332 ***

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	30.33
2	54.18	29.90
3	56.15	29.56
4	58.13	29.31
5	60.12	29.15
6	62.12	29.08
7	64.12	29.11
8	66.12	29.22
9	68.11	29.42
10	70.09	29.72
11	72.05	30.10
12	73.99	30.57
13	75.91	31.13
14	77.81	31.78
15	79.67	32.51
16	81.49	33.33
17	83.28	34.23
18	85.02	35.21
19	86.72	36.26
20	88.37	37.40
21	89.96	38.60
22	91.50	39.88
23	92.98	41.23
24	94.40	42.64
25	95.75	44.12
26	97.03	45.65
27	97.42	46.18

*** 1.350 ***

```
                                    Profile.out
             Y            A     X     I     S            F     T

                0.00      15.00     30.00     45.00     60.00     75.00
X       0.00 +---------+--------*+*---W----+---------+---------+
             -
             -
             -
             -
             -
       15.00 +
             -
             -
             -
             -
             -
A      30.00 +                    .
             -                  ...
             -                 ....
             -                .....
             -               ......
             -              ......*
X      45.00 +              ....*.
             -             ......6
             -             ......6
             -             ......4
             -            .......4
             -            .......64
I      60.00 +            ......064
             -            ......054.
             -            ......0541
             -            .......851
             -            .......851.
             -             ......8516
S      75.00 +            .......052*
             -            ........831 *
             -            .........821
             -            .........0221
             -            ..........9211
             -             ..........3221   *
       90.00 +             ..........932411.
             -             ...........932251
             -              ...........933255/1
             -              ...........993220
             -               ...........9.332
             -                ...........9943
F     105.00 +                .............9.1/
             -                  ...........99.
             -                  ............9
             -                    ............
             -                      ..........
             -                        .........
T     120.00 +                         *  W...*
```

Machines

- » Articulated Trucks
- » Backhoe Loaders
- » Cold Planers
- » Compactors
- » Feller Bunchers
- » Forest Machines
- » Forwarders
- » Harvesters
- » **Hydraulic Excavators**
- » Industrial Loaders
- » Knuckleboom Loaders
- » Material Handlers
- » Motor Graders
- » Multi Terrain Loaders
- » Off-Highway Tractors
- » Off-Highway Trucks
- » Paving Equipment
- » Pipelayers
- » Road Reclaimers
- » Scrapers
- » Skid Steer Loaders
- » Skidders
- » Telehandlers
- » Track Loaders
- » Track-Type Tractors
- » Underground Mining
- » Wheel Dozers
- » Wheel Excavators
- » Wheel Loaders

385C L HYDRAULIC EXCAVATOR

--- Select a Model ---

Overview | Specifications | Benefits & Features | Standard / Optional Equip. | Attachments / Work Tools

SPECIFICATIONS

Print Version

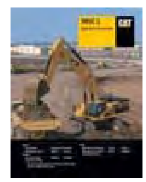
Engine	Units: US | Metric
Engine Model	Cat® C18 ACERT™
Net Flywheel Power	513 hp
Net Power - ISO 9249	513 hp
Net Power - SAE J1349	513 hp
Net Power - EEC 80/1269	513 hp
Bore	5.71 in
Stroke	7.2 in
Displacement	1106 in3

Weights	
Operating Weight	187360 lb
Operating Weight - Long Undercarriage	187360 lb

Drive	
Maximum Travel Speed	2.8 mph
Maximum Drawbar Pull - Long Undercarriage	133090 lb

Hydraulic System	
Main System - Maximum Flow (Total)	259 gal/min
Swing System - Maximum Flow	119 gal/min
Maximum Pressure - Equipment - Normal	4640 psi
Maximum Pressure - Equipment - Heavy Lift	5080 psi
Maximum Pressure - Travel	5080 psi
Maximum Pressure - Swing	3770 psi
Pilot System - Maximum flow	24 gal/min
Pilot System- Maximum pressure	600 psi
Boom Cylinder - Bore	8.27 in
Boom Cylinder - Stroke	77.4 in
Stick Cylinder - Bore	8.66 in
Stick Cylinder - Stroke	89.1 in
HB Family Bucket Cylinder - Bore	7.87 in
HB Family Bucket Cylinder - Stroke	57.1 in
JB Family Bucket Cylinder - Bore	8.66 in
JB Family Bucket Cylinder - Stroke	62.4 in

Service Refill Capacities	
Fuel Tank Capacity	327.6 gal
Cooling System	26.7 gal
Engine Oil	17.2 gal
Swing Drive (each)	5 gal
Final Drive (each)	5.6 gal
Hydraulic System (including tank)	263 gal
Hydraulic Tank	214 gal



385C L HYDRAULIC EXCAVATOR

Download Product Brochure (1420 KB .PDF)

Sound Performance

Performance	ANSI/SAE J1166 OCT98

Standards

Brakes	SAE J1026 APR90
Cab/FOGS	SAE J1356 FEB88 ISO10262

Swing Mechanism

Swing Speed	6.5 RPM
Swing Torque	191914 lb ft

Track

Standard w/Long Undercarriage	36 in
Optional for Long Undercarriage	30 in
Number of Shoes Each Side - Long Undercarriage	51
Number of Track Rollers Each Side - Long Undercarriage	9
Number of Carrier Rollers Each Side	3

Operating Specifications

Max Reach at Ground Level	56.4 ft
Max Digging Depth	38.6 ft
Bucket Digging Force	64530 lb
Stick Digging Force	55350 lb
Max Bucket Capacity	7.06 yd3
Nominal bucket weight	6795 lb
Bucket digging force - Normal	64530 lb

Dimensions

Transport width	151.2 in

LOG OF BORING ST-01

Client CMS Land Company
Project Name
Number 22/24-001
Location Petoskey, MI

Drill Contractor Prosonic
Drill Method Rotasonic
Drilling Started 9/15/06 Ended 9/15/06
Logged By JMA2

Elevation --
Total Depth 32.0

DEPTH FEET	ASTM	DESCRIPTION
	SM	0-0.3': Silty sand, dark brown (10YR 3/3), trace gravel, roots.
	SM	0.3-6': Silty sand with gravel, fine to medium grained sand with some coarse grained sand. Coarse sand is angular, gravel is angular to subrounded, cobbles are present. Variable percentage of fine, sand, and gravel through section. Dark grayish brown (10YR 4/2) and gray (10YR 6/2).
5		
	GM	6-8': Silty gravel with sand, cobbles are present. Sample similar to above except for greater gravel content. Dark grayish brown (10YR 4/2).
	GP GM	8-10': Gravel with sand and silt, angular gravel, layer of sand and gravel present. Dark grayish brown (10YR 4/2) with brown, white, red.
10	GP	10-11.5': Gravel with a little sand and trace silt. Platey and angular gravel clasts. Dark grayish brown (10YR 4/2).
	SM	11.5-14': Silty sand with gravel, sand is fine to coarse grained, gravel is fine to medium grained. Angular to rounded sand and gravel. Gray to dark gray (10YR 5/1-4/1).
	GP	14-20': Gravel with sand and little silt, sand is fine to coarse grained and angular to subrounded, gravel is angular. Dark grayish brown (10YR 4/2) with light gray.
15		
20	GP	20-20.7': Cobble. Split spoon refusal at 20.7ft.
	GP	20.7-24': Rotasonic core sample. Entire sample is a boulder or cobbles of concrete-like material. Well cemented, clasts of gravel in matrix supported material. Gray.
	GM	24-24.5': Silty gravel with sand, unconsolidated material of above sample.
25	GM	24.5-26': Silty gravel with sand, fine to coarse grained angular gravel, fine to coarse grained angular to subrounded sand. Grayish brown to very dark grayish brown (10YR 4/2-3/2).
	GP	26-28': Gravel, with little sand and trace silt. Angular sand and gravel, sand is mostly coarse with some fine grained. Very dark grayish brown (10YR 3/2).
	GM	28-30': Silty gravel with sand, angular to subrounded gravel, fine to coarse grained sand. Black and dark grayish brown (10YR 4/2).

(continued)

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Remarks

Additional data may have been collected in the field which is not included on this log.

LOG OF BORING ST-01

SHEET 2 OF 2

Client CMS Land Company
Project Name
Number 22/24-001
Location Petoskey, MI

Drill Contractor Prosonic
Drill Method Rotasonic
Drilling Started 9/15/06 Ended 9/15/06
Logged By JMA2

Elevation --
Total Depth 32.0

DEPTH FEET	SAMP. LENGTH & RECOVERY	SAMP. NUMBER		ASTM	LITHOLOGY	DESCRIPTION	DEPTH FEET
				GP		30-30.5': Refusal at 30.5ft. Gravel with a little sand and trace silt.	
						30.5-32': Bedrock. Limestone, black, fine grained, thinly to medium bedded, fossiliferous.	
						Water at approximately 5.8ft bgs based on moisture content in samples. End of Boring - 32 feet	
35							35
40							40
45							45
50							50
55							55

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Remarks

Additional data may have been collected in the field which is not included on this log.

LOG OF BORING ST-02

SHEET 1 OF 1

Client CMS Land Company
Project Name
Number 22/24-001
Location Petoskey, MI

Drill Contractor Prosonic
Drill Method Rotasonic
Drilling Started 9/14/06 Ended 9/14/06
Logged By JMA2

Elevation --
Total Depth 20.0

DEPTH FEET	SAMP. LENGTH & RECOVERY	SAMP. NUMBER		ASTM	LITHOLOGY	DESCRIPTION	DEPTH FEET
				SP		0-0.4': Sand, fine to medium grained, with roots, brown (7.5YR 4/3).	
				SM		0.4-3.7': Silty sand with a little gravel, fine to medium grained sand, dark grayish brown (10YR 4/2). Increases in silt and gravel content at 2ft. Color is gray (10YR 5/1) and black (10YR 2/1).	
5				ML		3.7-10': Silt with sand and trace gravel, sand is fine to medium grained, gravel is angular. Dark grayish brown (10YR 4/2), non-plastic silt. Increase in sand and gravel content at 6ft. Color is grayish brown (10YR 5/2). Increase in silt content at 8ft. Color is black (10YR 2/1). Silt is cohesive but non-plastic.	5
10				GM		10-12': Silty gravel with trace sand. Sandy silt is cohesive with low plasticity. Dark grayish brown (10YR 4/2).	10
15				GP GM		12-16': Gravel with sand and silt. Sand is fine to coarse grained and angular, silt is cohesive but non-plastic. Gravel is angular to rounded. Very dark gray (10YR 3/1). Color is brown (10YR 4/3) and gray (10YR 4/1).	15
20						16-20': Bedrock at 16ft. Limestone, grayish brown to dark grayish brown, fine grain to microcrystalline, thin to medium bedded, fossiliferous.	20
25						Water lever at 9.75ft bgs when boring at 12ft and no casing in hole. End of Boring - 20 feet	25

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Remarks

Additional data may have been collected in the field which is not included on this log.

LOG OF BORING ST-03

Client: CMS Land Company
Project Name:
Number: 22/24-001
Location: Petoskey, MI

Drill Contractor: Prosonic
Drill Method: Rotasonic
Drilling Started: 9/13/06 Ended: 9/14/06
Logged By: JMA2

Elevation: --
Total Depth: 40.0

DEPTH FEET	SAMP. LENGTH & RECOVERY	SAMP. NUMBER		ASTM	LITHOLOGY	DESCRIPTION	DEPTH FEET
				SM		0-0.5': Silty sand with trace gravel roots, very dark grayish brown (10YR 3/2).	
				SP SM		0.5-2': Sand with silt and gravel, fine grained sand, also contains cobbles. Light brownish gray (10YR 6/2) with dark brown and red brown.	
				GP GM		2-4': Gravel with silt and sand, cobbles present, angular gravel, color varies in layers and includes brown, gray, dark brown, and black.	
5				GM		4-6': Silty gravel with sand, with cobbles, silty and sandy lenses are present. Brown (10YR 4/3) and grayish brown (10YR 5/2).	5
				SM		6-10': Silty sand with gravel, cohesive but non-plastic silt, fine to medium grained sand, angular gravel, some angular coarse grained sand. Dark grayish brown (10YR 4/2) becoming dark gray (2.5Y 4/1) below 8ft.	
10				ML		10-16': Silt with sand, trace gravel except for cobbles at 12ft, cohesive, low plasticity, rapid dilatancy, fine to coarse grained sand, gravel and coarse sand is angular. Color is dark gray (2.5Y 4/1). Silt becoming non-plastic below 14ft and color is very dark grayish brown (2.5Y 3/2) with black.	10
15							15
				GP GM		16-17': Gravel with silt and sand, dark grayish brown (2.5Y 4/2) with dark gravel.	
				SM		17-18': Silty sand with gravel, sand is fine to medium grained, gravel is subangular to rounded, black.	
20				ML		18-22': Silt with sand and little gravel, cohesive with no to low plasticity, rapid dilatancy, dark gray (2.5Y 4/1) with black and light material.	20
				SM		22-24': Silty sand with gravel, fine to medium grained sand, angular gravel, black (5Y 2.5/1).	
25						24-26': No recovery in split spoon. Chunk of limestone gravel stuck in tip of split spoon.	25
				GP		26-27.5': Gravel with trace sand and silt, may be a shattered cobble, dark grayish brown (2.5Y 3/2).	
				CL		27.5-28': Clay with trace sand and gravel, high plasticity, laminated, greenish gray (10GY 5/1), (weathered shale?)	
				GP		28-30': Only a few angular gravel clasts recovered.	

(continued)

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Remarks

Additional data may have been collected in the field which is not included on this log.

LOG OF BORING ST-03

Client CMS Land Company
Project Name
Number 22/24-001
Location Petoskey, MI

Drill Contractor Prosonic
Drill Method Rotasonic
Drilling Started 9/13/06 Ended 9/14/06
Logged By JMA2

Elevation --
Total Depth 40.0

DEPTH FEET	SAMP. LENGTH & RECOVERY	SAMP. NUMBER		ASTM	LITHOLOGY	DESCRIPTION	DEPTH FEET
				SP/GP		30-32': Sand with gravel and trace silt and clay, rounded gravel, gray (2.5Y 6/1) and light brownish gray (2.5Y 6/2).	
35				GP		32-37': Gravel with sand, angular to subrounded, fine to coarse grained sand, dark grayish brown to very dark grayish brown (2.5Y 5/2-3/2).	35
						37-40': Bedrock. Limestone, fine grained, medium to massive bedded, with a few fossils, very dark gray to black.	
40						Water lever measured at 10.65ft when hole at 12ft with no casing in boring. End of Boring - 40 feet	40
45							45
50							50
55							55

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Remarks

Additional data may have been collected in the field which is not included on this log.

LOG OF BORING ST-04

SHEET 1 OF 1

Client CMS Land Company

Project Name

Number 22/24-001

Location Petoskey, MI

Drill Contractor Prosonic

Drill Method Rotasonic

Drilling Started 9/15/06 Ended 9/15/06

Logged By JMA2

Elevation --

Total Depth 6.5

DEPTH FEET	SAMP. LENGTH & RECOVERY	SAMP. NUMBER		ASTM	LITHOLOGY	DESCRIPTION	DEPTH FEET
				SM		0-2': Silty sand with gravel, sand is fine to medium grained, gravel is angular, brown (10YR 4/3).	
				ML		2-3.5': Silt with sand and gravel, fine to medium grained sand, angular gravel, slightly cohesive, non-plastic silt, brown, black, and gray.	
5						3.5-6.5': Bedrock. Limestone, fine grained, thinly to medium bedded, fossiliferous, very dark grayish brown.	5
						No water encountered in boring above bedrock. End of Boring - 6.5 feet	
10							10
15							15
20							20
25							25

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Remarks

Additional data may have been collected in the field which is not included on this log.

LOG OF BORING ST-05
SHEET 1 OF 1

Client CMS Land Company
Project Name
Number 22/24-001
Location Petoskey, MI

Drill Contractor Prosonic
Drill Method Rotasonic
Drilling Started 9/16/06 Ended 9/16/06
Logged By JMA2

Elevation --
Total Depth 8.0

DEPTH FEET	SAMP. LENGTH & RECOVERY	SAMP. NUMBER		ASTM	LITHOLOGY	DESCRIPTION	DEPTH FEET
				GM		0-6': Silty gravel with sand, fine to coarse grained, angular sand and gravel, gray (10YR 6/1), brown (10YR 4/3) and dark grayish brown (10YR 4/2).	
5							5
						6-8': Bedrock. Limestone, fine grained, thinly to medium bedded, fossiliferous, very dark grayish brown.	
						No water encountered in boring. End of Boring - 8 feet	
10							10
15							15
20							20
25							25

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Additional data may have been collected in the field which is not included on this log.

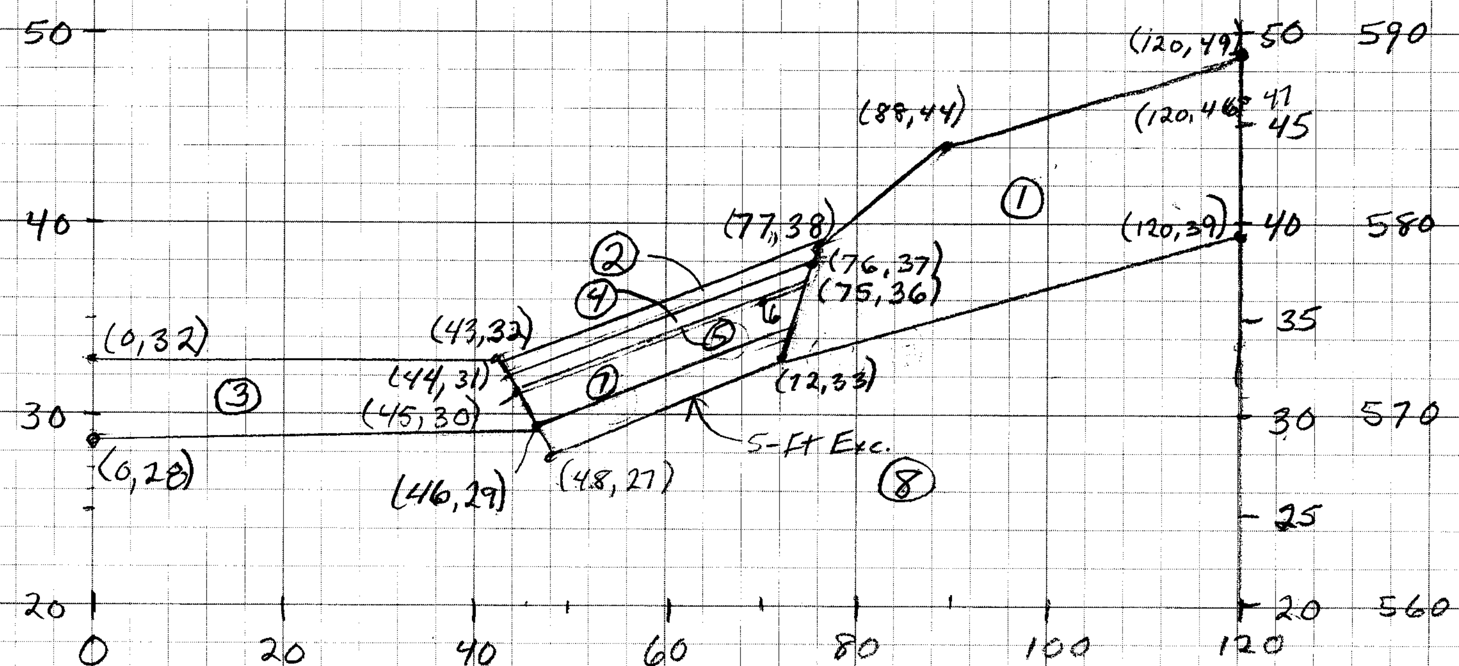
ARCADIS BBL

Appendix F

Cover Slope Stability Analyses –
Short-Term Condition

Slope Stability - Cover Analysis (Short Term)

Layer	Description of Soil or Material	γ_w (pcf)	γ_s (pcf)	C (psf)	ϕ (deg.)
1	Overburden - silty sand to silt, occ. gravel	105	115	0	22
2	Gravel - angular to round, w/silt & sand	130	135	0	35
3	Sediment -	75	80	50	15
4	Sand - fine to medium	105	110	0	30
5	GCL/Sand interface	115	125	0	18
6	GCL	115	125	500	0
7	Granular fill - sand/crushed pyrite	110	115	0	30
8	Limestone or Gravel	140	145	0	35



ARCADIS BBL

SUBJECT:

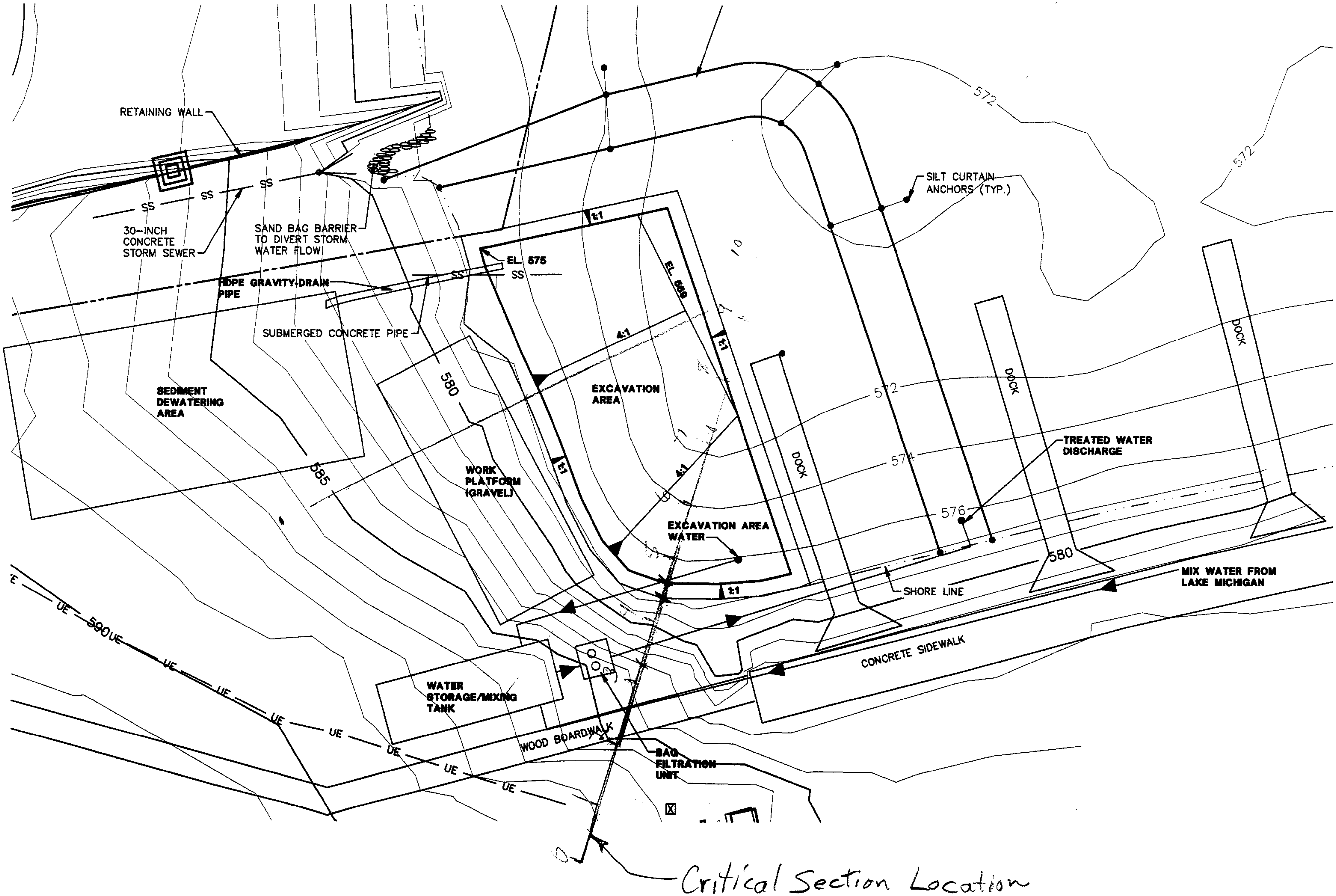
JOB NO:

BY: DATE:

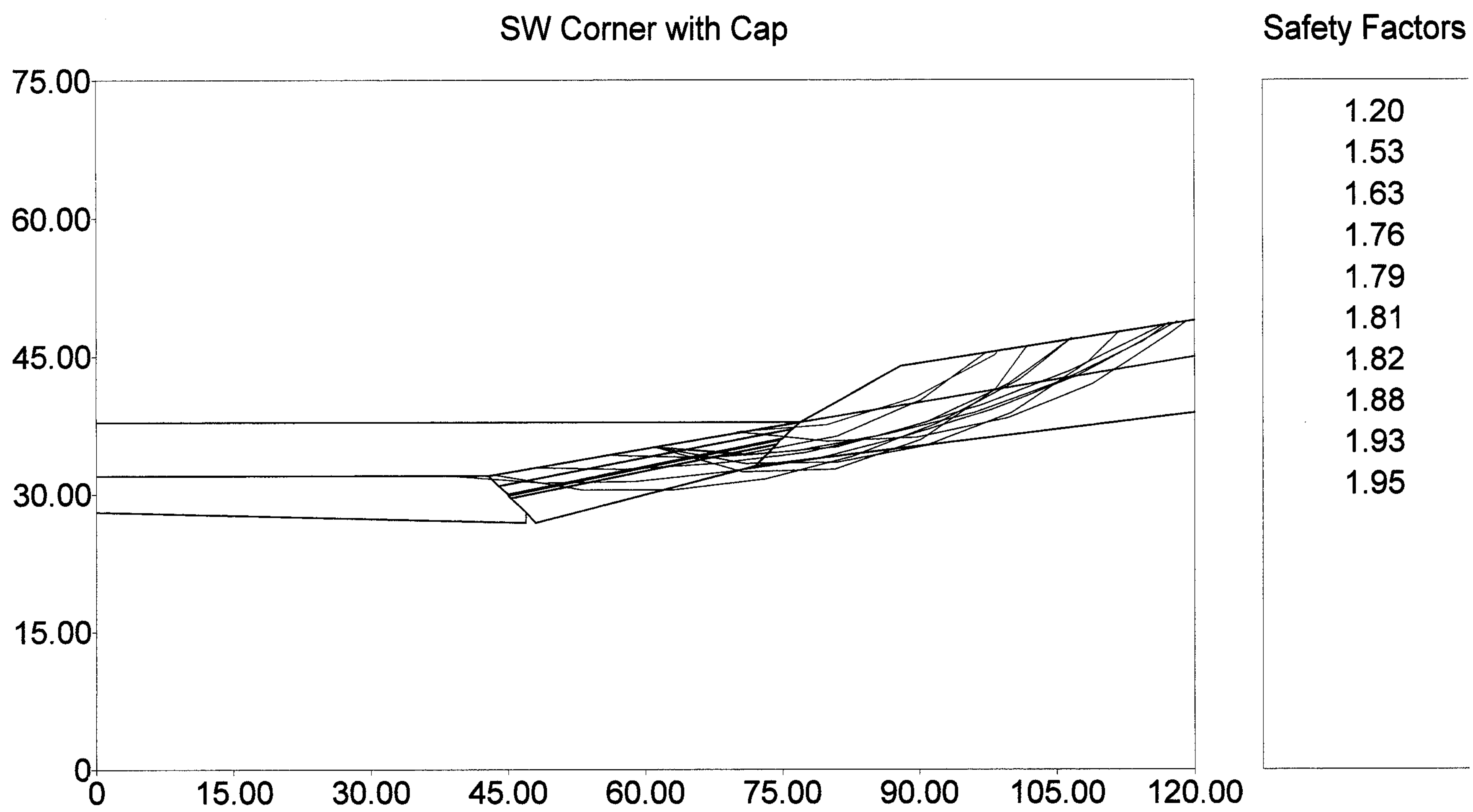
CHKD: DATE:

SHEET 1

PAGE



RETAINING WALL
30-INCH CONCRETE STORM SEWER
SAND BAG BARRIER TO DIVERT STORM WATER FLOW
HDPE GRAVITY-DRAIN PIPE
SUBMERGED CONCRETE PIPE
SS
SEDIMENT DEWATERING AREA
WORK PLATFORM (GRAVEL)
EXCAVATION AREA
EXCAVATION AREA WATER
EL. 575
EL. 569
1:1
4:1
SILT CURTAIN ANCHORS (TYP.)
DOCK
TREATED WATER DISCHARGE
SHORE LINE
MIX WATER FROM LAKE MICHIGAN
CONCRETE SIDEWALK
WATER STORAGE/MIXING TANK
WOOD BOARDWALK
BAG FILTRATION UNIT
UE
572
574
576
580
585
590
Critical Section Location



Circle 2 files

```
PROFIL
SW Corner with Cap
22 4
0.00 32.00 43.00 32.00 3
43.00 32.00 77.00 38.00 2
77.00 38.00 88.00 44.00 1
88.00 44.00 120.00 49.00 1
43.00 32.00 44.00 31.00 3
44.00 31.00 76.00 37.00 4
76.00 37.00 77.00 38.00 1
44.00 31.00 45.00 30.00 3
45.00 30.00 75.00 36.00 5
75.00 36.00 76.00 37.00 1
45.00 30.00 45.20 29.80 3
45.20 29.80 74.80 35.80 6
74.80 35.80 75.00 36.00 1
45.20 29.80 45.40 29.60 3
45.40 29.60 74.60 35.60 7
74.60 35.60 74.80 35.80 1
45.40 29.60 47.00 28.00 3
0.00 28.00 47.00 27.00 8
47.00 28.00 48.00 27.00 8
48.00 27.00 72.00 33.00 8
72.00 33.00 74.60 35.60 1
72.00 33.00 120.00 39.00 8
SOIL
8
105.00 115.00 0.00 22.00 0.00 0.00 2
130.00 135.00 0.00 35.00 0.00 0.00 1
75.00 80.00 50.00 15.00 0.00 0.00 1
105.00 110.00 0.00 30.00 0.00 0.00 1
115.00 125.00 0.00 18.00 0.00 0.00 1
115.00 125.00 500.00 0.00 0.00 0.00 1
110.00 115.00 0.00 30.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 45.00
CIRCL2
10 10 30.00 70.00 90.00 120.00 20.00 10.00 5.00 -80.00
```

Profile_circle2_out.out.txt
** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION   SW Corner with Cap

BOUNDARY COORDINATES

4 Top Boundaries
22 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	3
2	43.00	32.00	77.00	38.00	2
3	77.00	38.00	88.00	44.00	1
4	88.00	44.00	120.00	49.00	1
5	43.00	32.00	44.00	31.00	3
6	44.00	31.00	76.00	37.00	4
7	76.00	37.00	77.00	38.00	1
8	44.00	31.00	45.00	30.00	3
9	45.00	30.00	75.00	36.00	5
10	75.00	36.00	76.00	37.00	1
11	45.00	30.00	45.20	29.80	3
12	45.20	29.80	74.80	35.80	6
13	74.80	35.80	75.00	36.00	1
14	45.20	29.80	45.40	29.60	3
15	45.40	29.60	74.60	35.60	7
16	74.60	35.60	74.80	35.80	1
17	45.40	29.60	47.00	28.00	3
18	0.00	28.00	47.00	27.00	8
19	47.00	28.00	48.00	27.00	8
20	48.00	27.00	72.00	33.00	8
21	72.00	33.00	74.60	35.60	1
22	72.00	33.00	120.00	39.00	8

ISOTROPIC SOIL PARAMETERS

8 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	22.0	0.00	0.0	2
2	130.0	135.0	0.0	35.0	0.00	0.0	1
3	75.0	80.0	50.0	15.0	0.00	0.0	1
4	105.0	110.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	0.0	18.0	0.00	0.0	1
6	115.0	125.0	500.0	0.0	0.00	0.0	1
7	110.0	115.0	0.0	30.0	0.00	0.0	1
8	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	45.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 30.00 ft.
and X = 70.00 ft.

Each Surface Terminates Between X = 90.00 ft.
and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 20.00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -80.0
And 5.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	36.76
2	79.96	37.61
3	89.54	40.50
4	98.31	45.31
5	98.74	45.68

Circle Center At X = 70.9 ; Y = 84.9 and Radius, 48.1

*** 1.195 ***

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	71.09	34.55
3	80.95	36.23
4	90.15	40.15
5	97.31	45.45

Circle Center At X = 68.9 ; Y = 77.3 and Radius, 42.8

*** 1.526 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	71.08	34.40
3	81.04	35.31
4	90.70	37.90

5	99.78	42.09
6	106.83	46.94

Circle Center At X = 70.7 ; Y = 93.1 and Radius, 58.7

*** 1.634 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	70.73	32.45
3	80.72	32.66
4	90.22	35.81
5	98.35	41.62
6	101.82	46.16

Circle Center At X = 75.0 ; Y = 65.7 and Radius, 33.5

*** 1.764 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	36.76
2	79.94	35.66
3	89.92	36.20
4	99.69	38.38
5	108.96	42.12
6	117.49	47.34
7	119.28	48.89

Circle Center At X = 81.6 ; Y = 96.4 and Radius, 60.8

*** 1.792 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	70.94	33.37
3	80.94	33.42
4	90.76	35.34
5	100.04	39.07
6	108.45	44.47

7	111.90	47.73

Circle Center At X = 75.7 ; Y = 86.3 and Radius, 53.1

*** 1.812 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.67	34.41
2	66.66	34.10
3	76.64	34.76
4	86.51	36.38
5	96.17	38.95
6	105.54	42.45
7	114.52	46.84
8	117.36	48.59

Circle Center At X = 64.9 ; Y = 137.1 and Radius, 103.0

*** 1.815 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.78	32.84
2	57.78	32.68
3	67.76	33.28
4	77.66	34.66
5	87.43	36.81
6	97.00	39.70
7	106.32	43.32
8	115.33	47.66
9	116.77	48.50

Circle Center At X = 54.9 ; Y = 161.7 and Radius, 129.0

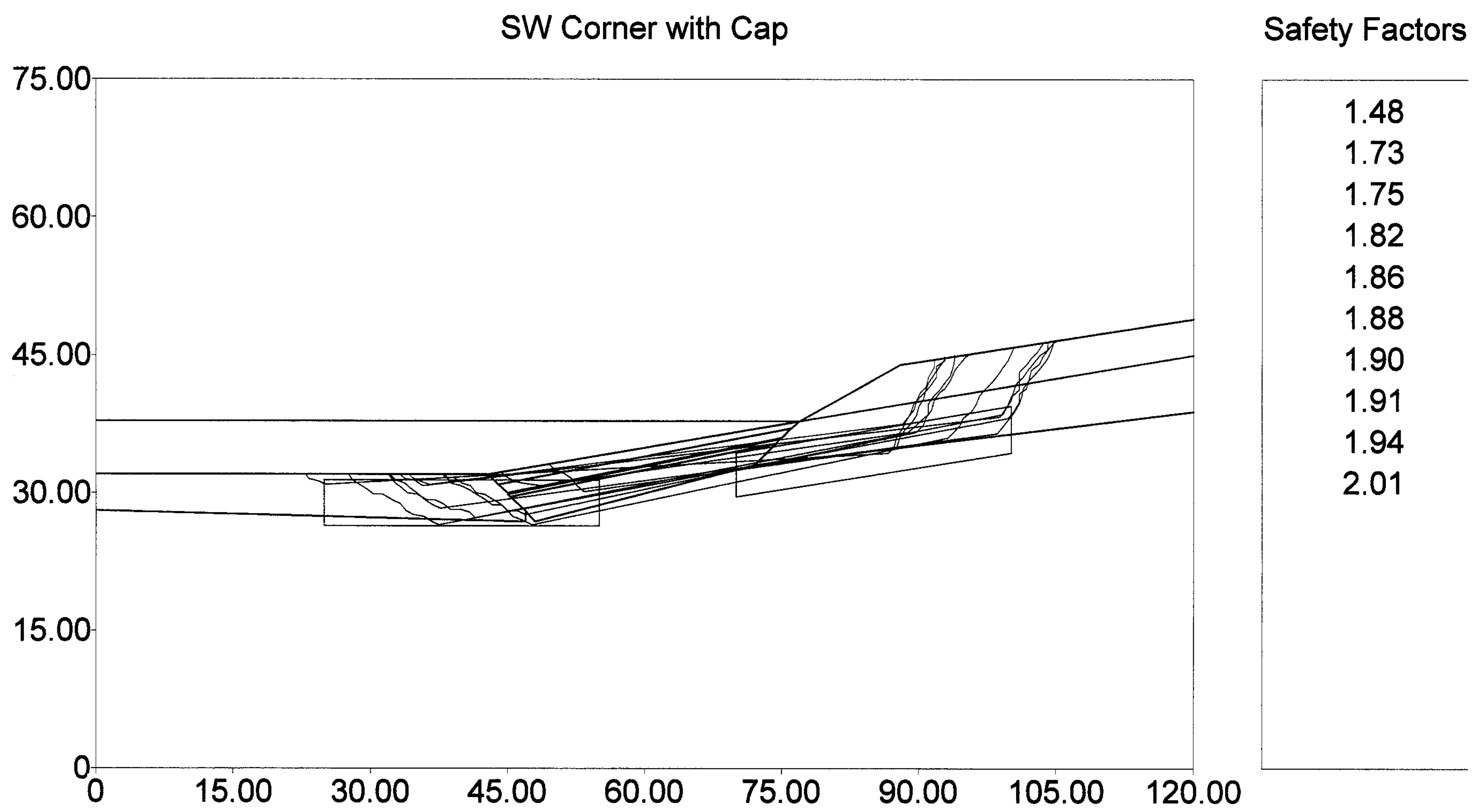
*** 1.881 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.33	32.06
2	53.24	30.67
3	63.24	30.56

```
    4          73.17         31.73
    5          82.87         34.17
    6          92.17         37.82
    7         100.94         42.64
    8         106.82         46.94

Circle Center At X =    59.1 ; Y =   108.4  and Radius,    77.9


      ***      1.933    ***


Failure Surface Specified By 10 Coordinate Points


  Point        X-Surf       Y-Surf
   No.          (ft)         (ft)

    1          38.89         32.00
    2          48.87         31.36
    3          58.87         31.47
    4          68.83         32.33
    5          78.70         33.93
    6          88.43         36.27
    7          97.95         39.33
    8         107.21         43.09
    9         116.17         47.53
   10         118.16         48.71

Circle Center At X =    52.4 ; Y =   164.9  and Radius,   133.6


      ***      1.952    ***




           Y            A     X     I     S            F     T

           0.00     15.00     30.00     45.00     60.00     75.00

X      0.00 +---------+--------*+*---W----+---------+---------+
            -
            -
            -
            -
            -
      15.00 +
            -
            -
            -
            -
            -
A     30.00 +                    .
            -
            -                    .
            -                ..
            -                 . .0
            -                ... *
X     45.00 +                . .**
```

```
            -             ....**  8
            -                ".  .0"
            -             ......9 .
            -             .. ..   .
            -            ........ 87
I     60.00 +             .. ....0.2
            -            .......9..
            -             ......... .
            -            .......  87
            -            ... .   .42 1
            -             .......9*.
S     75.00 +               ........**
            -            ........  7 *
            -              ..... . 4.21
            -              ........9 .
            -                ......   .
            -             ......... 78   *
      90.00 +                ...... 43.1  .
            -               ... . ...9... .
            -                 ........7   .
            -                .. ..  ..8.4.1
            -                 ....... 5.3...
            -                 ..   ........4
F    105.00 +                   ..... . 7...
            -                    . ......863
            -                     .. . .5....
            -                         ......6
            -                       .. .....78
            -                           . ..5.
T    120.00 +                         *   W. *
```



Block 4 files

```
PROFIL
SW Corner with Cap
22 4
0.00 32.00 43.00 32.00 3
43.00 32.00 77.00 38.00 2
77.00 38.00 88.00 44.00 1
88.00 44.00 120.00 49.00 1
43.00 32.00 44.00 31.00 3
44.00 31.00 76.00 37.00 4
76.00 37.00 77.00 38.00 1
44.00 31.00 45.00 30.00 3
45.00 30.00 75.00 36.00 5
75.00 36.00 76.00 37.00 1
45.00 30.00 45.20 29.80 3
45.20 29.80 74.80 35.80 6
74.80 35.80 75.00 36.00 1
45.20 29.80 45.40 29.60 3
45.40 29.60 74.60 35.60 7
74.60 35.60 74.80 35.80 1
45.40 29.60 47.00 28.00 3
0.00 28.00 47.00 27.00 8
47.00 28.00 48.00 27.00 8
48.00 27.00 72.00 33.00 8
72.00 33.00 74.60 35.60 1
72.00 33.00 120.00 39.00 8
SOIL
8
105.00 115.00 0.00 18.00 0.00 0.00 2
130.00 135.00 0.00 35.00 0.00 0.00 1
75.00 80.00 50.00 15.00 0.00 0.00 1
105.00 110.00 0.00 30.00 0.00 0.00 1
115.00 125.00 0.00 18.00 0.00 0.00 1
115.00 125.00 500.00 0.00 0.00 0.00 1
110.00 115.00 0.00 30.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 45.00
BLOCK
50 2 1.00
25.00 29.00 55.00 29.00 5.00
70.00 32.00 100.00 37.00 5.00
```

** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION   SW Corner with Cap

BOUNDARY COORDINATES

4 Top   Boundaries
22 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	3
2	43.00	32.00	77.00	38.00	2
3	77.00	38.00	88.00	44.00	1
4	88.00	44.00	120.00	49.00	1
5	43.00	32.00	44.00	31.00	3
6	44.00	31.00	76.00	37.00	4
7	76.00	37.00	77.00	38.00	1
8	44.00	31.00	45.00	30.00	3
9	45.00	30.00	75.00	36.00	5
10	75.00	36.00	76.00	37.00	1
11	45.00	30.00	45.20	29.80	3
12	45.20	29.80	74.80	35.80	6
13	74.80	35.80	75.00	36.00	1
14	45.20	29.80	45.40	29.60	3
15	45.40	29.60	74.60	35.60	7
16	74.60	35.60	74.80	35.80	1
17	45.40	29.60	47.00	28.00	3
18	0.00	28.00	47.00	27.00	8
19	47.00	28.00	48.00	27.00	8
20	48.00	27.00	72.00	33.00	8
21	72.00	33.00	74.60	35.60	1
22	72.00	33.00	120.00	39.00	8

ISOTROPIC SOIL PARAMETERS

8 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	18.0	0.00	0.0	2
2	130.0	135.0	0.0	35.0	0.00	0.0	1
3	75.0	80.0	50.0	15.0	0.00	0.0	1
4	105.0	110.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	0.0	18.0	0.00	0.0	1
6	115.0	125.0	500.0	0.0	0.00	0.0	1
7	110.0	115.0	0.0	30.0	0.00	0.0	1
8	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	45.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

50 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is   1.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	25.00	29.00	55.00	29.00	5.00
2	70.00	32.00	100.00	37.00	5.00

Following Are Displayed The Ten Most Critical Of The Trial

Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	34.31	32.00
2	34.64	31.76
3	35.53	31.31
4	36.51	31.12
5	88.27	37.50
6	88.81	38.34
7	89.35	39.18
8	89.84	40.05
9	90.34	40.92
10	90.88	41.76
11	91.09	42.74
12	91.63	43.58
13	91.71	44.58

*** 1.484 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	49.59	33.16
2	50.27	32.49
3	51.18	32.08
4	52.06	31.60
5	52.81	30.94
6	53.53	30.24
7	87.74	35.14
8	87.90	36.13
9	88.55	36.89
10	89.21	37.64
11	89.66	38.54
12	89.97	39.49
13	90.59	40.27
14	90.76	41.26
15	91.27	42.12
16	91.70	43.02
17	92.40	43.73
18	92.93	44.58
19	92.97	44.78

*** 1.731 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.04	32.00
2	38.24	31.82
3	39.23	31.78
4	40.07	31.23
5	40.99	30.84
6	41.73	30.16
7	42.65	29.78
8	43.54	29.32
9	44.41	28.84
10	45.21	28.23
11	46.20	28.14
12	47.01	27.55
13	89.78	36.62
14	90.48	37.34
15	90.94	38.23
16	91.31	39.15
17	91.81	40.02
18	92.27	40.91
19	92.97	41.62
20	93.40	42.52
21	93.88	43.40
22	94.58	44.11
23	95.23	44.88
24	95.38	45.15

*** 1.749 ***

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	32.03	32.00
2	32.76	31.47
3	33.73	31.24
4	34.54	30.65
5	35.27	29.97
6	36.01	29.30
7	36.86	28.77
8	37.80	28.43
9	98.56	36.50
10	99.20	37.26
11	99.79	38.08
12	100.33	38.92
13	100.93	39.71
14	101.30	40.64
15	101.56	41.61
16	102.20	42.38
17	102.47	43.34
18	103.17	44.06
19	103.67	44.92
20	104.30	45.70
21	104.90	46.50

22	105.00	46.66

*** 1.818 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.90	32.00
2	30.98	31.94
3	31.98	31.91
4	32.70	31.22
5	33.45	30.55
6	34.24	29.94
7	35.23	29.79
8	36.08	29.27
9	37.08	29.24
10	38.04	28.95
11	38.87	28.41
12	39.87	28.35
13	40.75	27.86
14	41.58	27.32
15	99.27	38.69
16	99.77	39.56
17	100.21	40.46
18	100.89	41.19
19	100.95	42.18
20	101.14	43.17
21	101.83	43.89
22	102.35	44.74
23	103.06	45.45
24	103.62	46.28
25	103.64	46.44

*** 1.861 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.60	32.00
2	28.08	31.57
3	28.90	30.99
4	29.77	30.51
5	30.51	29.83
6	31.51	29.79
7	32.35	29.25
8	33.28	28.88
9	34.03	28.22
10	34.86	27.67
11	35.83	27.42
12	36.71	26.95
13	37.67	26.66

14	99.81	38.19
15	100.45	38.96
16	100.93	39.84
17	101.08	40.82
18	101.78	41.54
19	102.18	42.45
20	102.87	43.18
21	103.58	43.89
22	104.21	44.66
23	104.46	45.63
24	104.92	46.52
25	104.92	46.64

*** 1.875 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	44.32	32.23
2	44.97	31.77
3	45.86	31.31
4	46.85	31.17
5	47.84	30.99
6	48.84	30.96
7	88.98	36.57
8	89.69	37.28
9	90.37	38.01
10	91.08	38.71
11	91.15	39.71
12	91.64	40.58
13	92.26	41.37
14	92.94	42.11
15	93.51	42.93
16	93.69	43.91
17	93.93	44.88
18	93.96	44.93

*** 1.899 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.32	32.00
2	33.92	31.58
3	34.92	31.54
4	35.63	30.84
5	98.99	38.43
6	99.45	39.32
7	100.07	40.10
8	100.41	41.04
9	100.73	41.99

10	101.38	42.75
11	102.06	43.48
12	102.71	44.24
13	103.40	44.96
14	104.08	45.70
15	104.11	46.52

*** 1.911 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.04	32.00
2	23.38	31.71
3	24.31	31.35
4	25.24	30.98
5	86.68	34.44
6	87.33	35.20
7	87.79	36.08
8	88.16	37.01
9	88.68	37.87
10	89.05	38.80
11	89.40	39.74
12	90.10	40.44
13	90.81	41.15
14	91.30	42.02
15	91.99	42.75
16	92.16	43.74
17	92.87	44.44
18	92.90	44.77

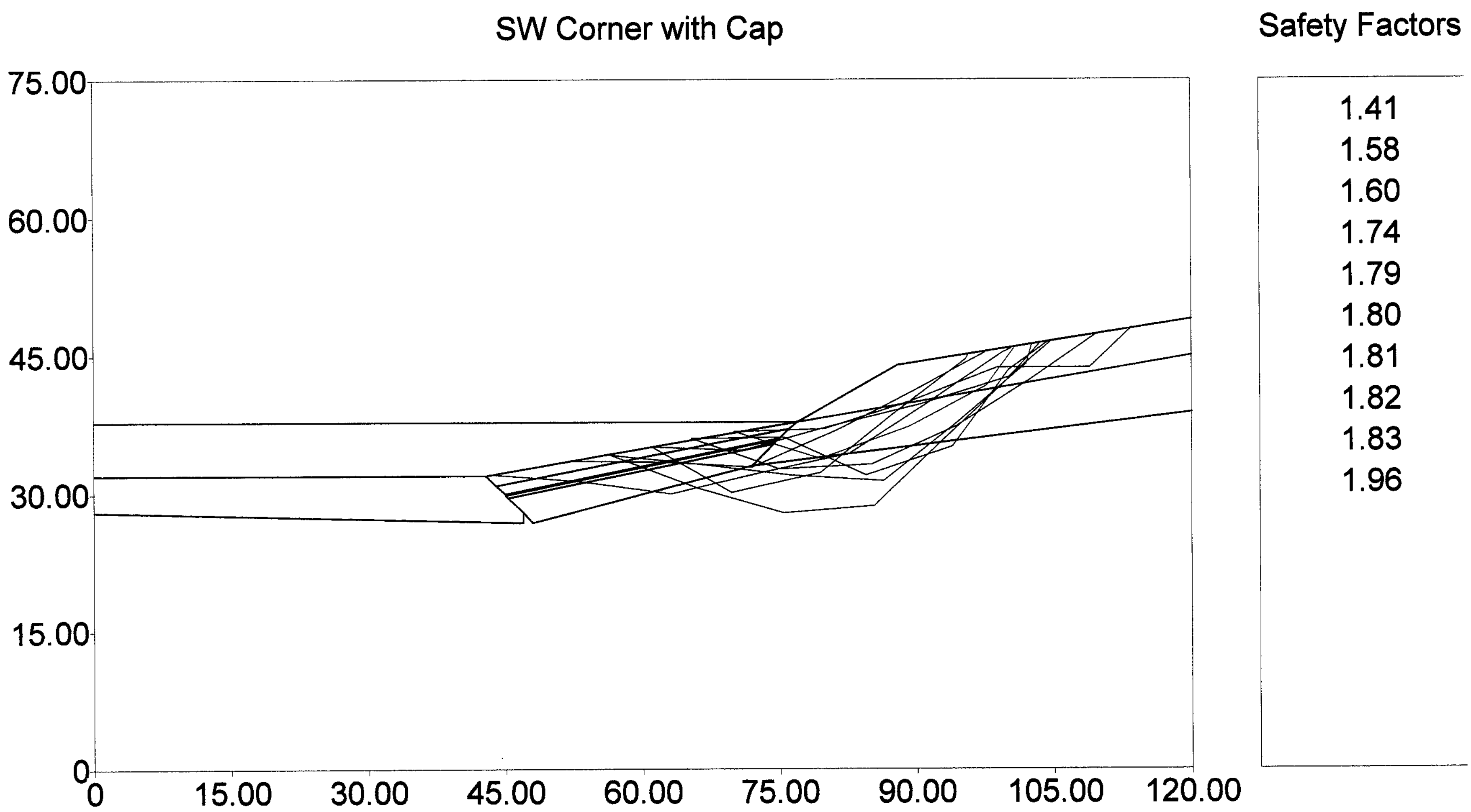
*** 1.944 ***

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	37.87	32.00
2	38.26	31.91
3	38.97	31.20
4	39.92	30.91
5	40.77	30.38
6	41.65	29.91
7	42.50	29.38
8	43.33	28.82
9	44.33	28.82
10	45.04	28.11
11	45.79	27.45
12	46.76	27.19
13	47.64	26.71
14	93.11	35.95
15	93.82	36.66

```
  16          94.51        37.38
  17          94.95        38.28
  18          95.63        39.01
  19          96.31        39.74
  20          96.59        40.70
  21          97.30        41.41
  22          98.00        42.12
  23          98.60        42.92
  24          99.31        43.62
  25          99.96        44.38
  26         100.20        45.35
  27         100.33        45.93

     ***      2.007    ***



           Y            A     X     I     S            F     T

           0.00     15.00     30.00     45.00     60.00     75.00

X      0.00 +---------+--------*+*---W----+---------+---------+
            -
            -
            -
            -
            -
      15.00 +
            -                    .
            -                   ..
            -                  ..9
            -                 ...9
            -                 ...6
A     30.00 +                 ..65
            -                 .654
            -                 6641
            -                 64.1
            -                 .503
            -                 503*
X     45.00 +                 03**.
            -                 **.7.
            -                 ...22
            -                  .22
            -                   .
            -
I     60.00 +
            -
            -
            -
            -                    .....
            -                   ..*...
S     75.00 +                    ...**
            -                    ....*.
            -                     ......
            -                     .......
            -                    .........
            -                      221...*
      90.00 +                     ..32111..
            -                      .0.33211
```

```
               -                  .000..33
               -                   4.0000.
               -                    .4455500
               -                      .44445
F     105.00 +                          .44
               -                          .
               -
               -
               -
               -
T     120.00 +                      *    W   *
```



Irregular surface / files

```
PROFIL
SW Corner with Cap
22 4
0.00 32.00 43.00 32.00 3
43.00 32.00 77.00 38.00 2
77.00 38.00 88.00 44.00 1
88.00 44.00 120.00 49.00 1
43.00 32.00 44.00 31.00 3
44.00 31.00 76.00 37.00 4
76.00 37.00 77.00 38.00 1
44.00 31.00 45.00 30.00 3
45.00 30.00 75.00 36.00 5
75.00 36.00 76.00 37.00 1
45.00 30.00 45.20 29.80 3
45.20 29.80 74.80 35.80 6
74.80 35.80 75.00 36.00 1
45.20 29.80 45.40 29.60 3
45.40 29.60 74.60 35.60 7
74.60 35.60 74.80 35.80 1
45.40 29.60 47.00 28.00 3
0.00 28.00 47.00 27.00 8
47.00 28.00 48.00 27.00 8
48.00 27.00 72.00 33.00 8
72.00 33.00 74.60 35.60 1
72.00 33.00 120.00 39.00 8
SOIL
8
105.00 115.00 0.00 22.00 0.00 0.00 2
130.00 135.00 0.00 35.00 0.00 0.00 1
75.00 80.00 50.00 15.00 0.00 0.00 1
105.00 110.00 0.00 30.00 0.00 0.00 1
115.00 125.00 0.00 18.00 0.00 0.00 1
115.00 125.00 500.00 0.00 0.00 0.00 1
110.00 115.00 0.00 30.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 45.00
RANDOM
10 10 30.00 70.00 90.00 120.00 20.00 10.00 5.00 -60.00
```

** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION SW Corner with Cap

BOUNDARY COORDINATES

4 Top Boundaries
22 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	3
2	43.00	32.00	77.00	38.00	2
3	77.00	38.00	88.00	44.00	1
4	88.00	44.00	120.00	49.00	1
5	43.00	32.00	44.00	31.00	3
6	44.00	31.00	76.00	37.00	4
7	76.00	37.00	77.00	38.00	1
8	44.00	31.00	45.00	30.00	3
9	45.00	30.00	75.00	36.00	5
10	75.00	36.00	76.00	37.00	1
11	45.00	30.00	45.20	29.80	3
12	45.20	29.80	74.80	35.80	6
13	74.80	35.80	75.00	36.00	1
14	45.20	29.80	45.40	29.60	3
15	45.40	29.60	74.60	35.60	7
16	74.60	35.60	74.80	35.80	1
17	45.40	29.60	47.00	28.00	3
18	0.00	28.00	47.00	27.00	8
19	47.00	28.00	48.00	27.00	8
20	48.00	27.00	72.00	33.00	8
21	72.00	33.00	74.60	35.60	1
22	72.00	33.00	120.00	39.00	8

ISOTROPIC SOIL PARAMETERS

8 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	22.0	0.00	0.0	2
2	130.0	135.0	0.0	35.0	0.00	0.0	1
3	75.0	80.0	50.0	15.0	0.00	0.0	1
4	105.0	110.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	0.0	18.0	0.00	0.0	1
6	115.0	125.0	500.0	0.0	0.00	0.0	1
7	110.0	115.0	0.0	30.0	0.00	0.0	1
8	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	45.00

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Irregular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 30.00 ft.
and X = 70.00 ft.

Each Surface Terminates Between X = 90.00 ft.
and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 20.00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -60.0 And 5.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	36.76
2	79.60	33.95
3	89.07	37.15
4	97.87	41.90
5	100.59	45.97

*** 1.409 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	36.76
2	80.00	37.01
3	89.53	40.04
4	98.88	43.58
5	108.88	43.59
6	113.68	48.01

*** 1.578 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	35.98
2	75.03	32.77
3	85.02	33.14
4	94.14	37.24
5	102.60	42.57
6	109.91	47.42

*** 1.599 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.67	34.41
2	66.59	33.19
3	76.52	31.96
4	86.50	31.48
5	94.40	37.63
6	102.01	44.11
7	102.78	46.31

*** 1.736 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	69.87	30.36
3	79.69	32.22
4	87.37	38.63
5	95.45	44.53
6	95.91	45.24

*** 1.791 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	71.10	34.73
3	80.77	37.28
4	90.45	39.78
5	100.01	42.71
6	104.90	46.64

*** 1.796 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	33.63
2	62.22	33.41
3	72.21	32.88
4	81.38	36.86
5	90.20	41.58
6	97.56	45.49

*** 1.814 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.33	32.06
2	53.31	31.43
3	63.22	30.08
4	72.97	32.31
5	82.74	34.47
6	91.24	39.73
7	99.48	45.40
8	100.29	45.92

*** 1.815 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	35.98
2	75.55	36.15
3	84.64	31.98
4	94.08	35.29
5	100.01	43.34
6	104.55	46.59

*** 1.831 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.67	34.41
2	65.97	30.74
3	75.57	27.96
4	85.53	28.85

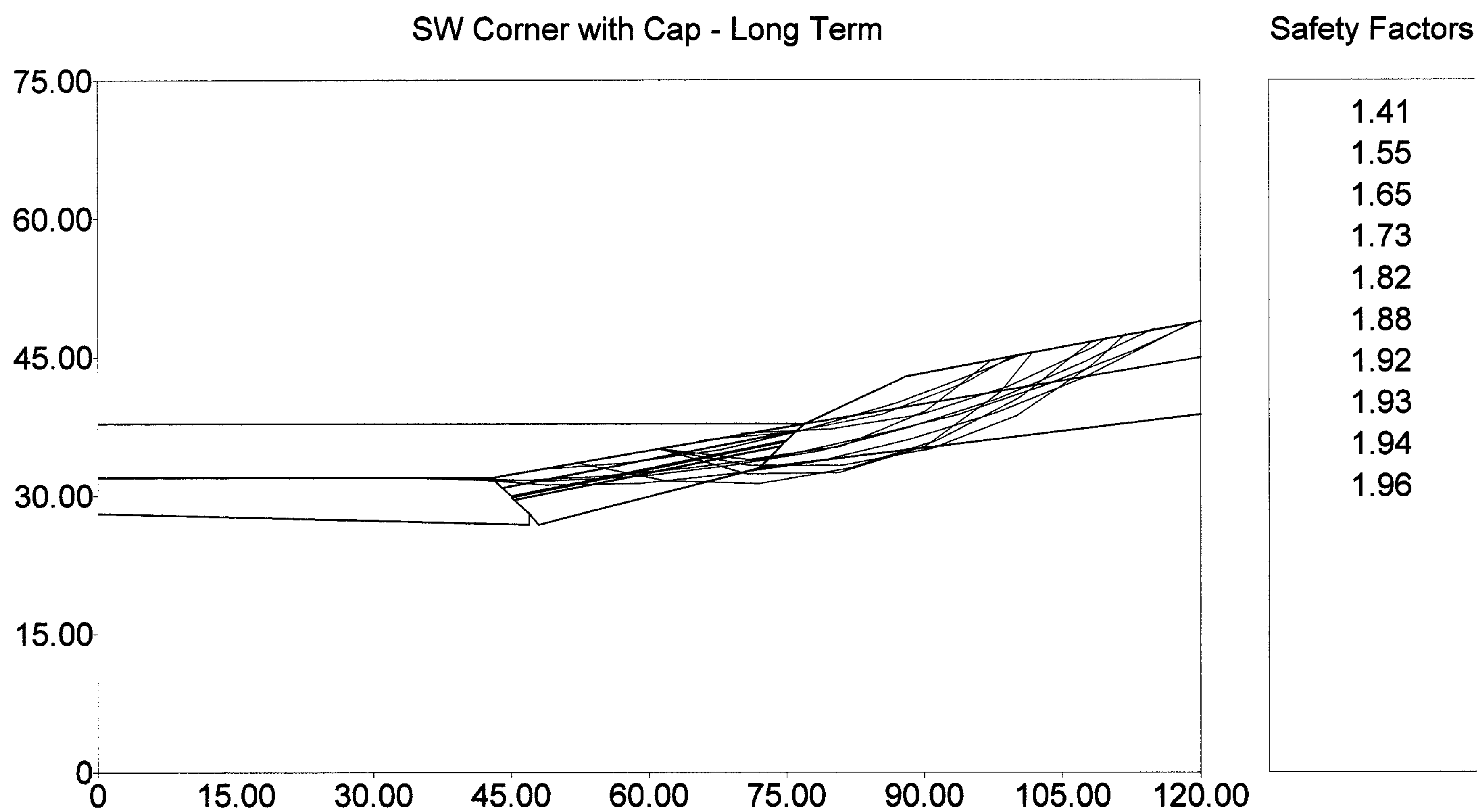
```
    5          92.79        35.74
    6         100.06        42.60
    7         103.58        46.43


     ***       1.962    ***



             Y            A     X     I     S            F     T

              0.00     15.00     30.00     45.00     60.00     75.00
X       0.00 +---------+--------*+*---W----+---------+---------+
             -
             -
             -
             -
             -
       15.00 +
             -
             -
             -
             -
             -
A      30.00 +                    .
             -
             -               .    .
             -               . .
             -               .  ...
             -                ... *
X      45.00 +            .. ..  **
             -              ...**. .
             -            .. .....
             -            ..... . 87
             -            ......
             -             .....  . 4
I      60.00 +            .......   5
             -            ...... 8 7
             -             ..... 0   3
             -             ....... 4
             -            .......5  6 1
             -            ........ *
S      75.00 +            ......0. 3.**
             -            ........4   *
             -            ....... 5 1 2
             -             .........8.7
             -            ......0.93. ...
             -             . .....4..  5. *
       90.00 +            .. .........1827..
             -             ......   .0.. ...
             -             .... .....93.. .5
             -               ....... .. .1 7
             -               .  ... .. ..6281
             -               . ... ......34.4
F     105.00 +               ...  .... .... 6
             -                   ......... ..
             -                    . .. ...2..3
             -                     . . ......2
             -                        .. . . .
```

```
T     120.00 +                              *  W  *
```

ARCADIS BBL

Appendix G

Cover Slope Stability Analyses –
Long-Term Condition


SW Corner with Cap - Long Term
75.00
60.00
45.00
30.00
15.00
0
0
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
Safety Factors
1.41
1.55
1.65
1.73
1.82
1.88
1.92
1.93
1.94
1.96

```
PROFIL
SW Corner with Cap - Long Term
22 4
0.00 32.00 43.00 32.00 3
43.00 32.00 77.00 38.00 2
77.00 38.00 88.00 43.00 1
88.00 43.00 120.00 49.00 1
43.00 32.00 44.00 31.00 3
44.00 31.00 76.00 37.00 4
76.00 37.00 77.00 38.00 1
44.00 31.00 45.00 30.00 3
45.00 30.00 75.00 36.00 5
75.00 36.00 76.00 37.00 1
45.00 30.00 45.20 29.80 3
45.20 29.80 74.80 35.80 6
74.80 35.80 75.00 36.00 1
45.20 29.80 45.40 29.60 3
45.40 29.60 74.60 35.60 7
74.60 35.60 74.80 35.80 1
45.40 29.60 47.00 28.00 3
0.00 28.00 47.00 27.00 8
47.00 28.00 48.00 27.00 8
48.00 27.00 72.00 33.00 8
72.00 33.00 74.60 35.60 1
72.00 33.00 120.00 39.00 8
SOIL
8
105.00 115.00 0.00 22.00 0.00 0.00 2
130.00 135.00 0.00 35.00 0.00 0.00 1
75.00 80.00 50.00 15.00 0.00 0.00 1
105.00 110.00 0.00 30.00 0.00 0.00 1
115.00 125.00 0.00 18.00 0.00 0.00 1
115.00 125.00 0.00 8.00 0.00 0.00 1
110.00 115.00 0.00 30.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 45.00
CIRCL2
10 10 30.00 70.00 90.00 120.00 20.00 10.00 5.00 -75.00
```

Profile_circle2_LTcap.out.txt
** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION   SW Corner with Cap - Long Term

BOUNDARY COORDINATES

4 Top Boundaries
22 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	3
2	43.00	32.00	77.00	38.00	2
3	77.00	38.00	88.00	43.00	1
4	88.00	43.00	120.00	49.00	1
5	43.00	32.00	44.00	31.00	3
6	44.00	31.00	76.00	37.00	4
7	76.00	37.00	77.00	38.00	1
8	44.00	31.00	45.00	30.00	3
9	45.00	30.00	75.00	36.00	5
10	75.00	36.00	76.00	37.00	1
11	45.00	30.00	45.20	29.80	3
12	45.20	29.80	74.80	35.80	6
13	74.80	35.80	75.00	36.00	1
14	45.20	29.80	45.40	29.60	3
15	45.40	29.60	74.60	35.60	7
16	74.60	35.60	74.80	35.80	1
17	45.40	29.60	47.00	28.00	3
18	0.00	28.00	47.00	27.00	8
19	47.00	28.00	48.00	27.00	8
20	48.00	27.00	72.00	33.00	8
21	72.00	33.00	74.60	35.60	1
22	72.00	33.00	120.00	39.00	8

ISOTROPIC SOIL PARAMETERS

8 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	22.0	0.00	0.0	2
2	130.0	135.0	0.0	35.0	0.00	0.0	1
3	75.0	80.0	50.0	15.0	0.00	0.0	1
4	105.0	110.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	0.0	18.0	0.00	0.0	1
6	115.0	125.0	0.0	8.0	0.00	0.0	1
7	110.0	115.0	0.0	30.0	0.00	0.0	1
8	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	45.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 30.00 ft. and X = 70.00 ft.

Each Surface Terminates Between X = 90.00 ft. and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 20.00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -75.0
And 5.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.56	35.98
2	75.52	36.83
3	85.28	39.01
4	94.67	42.46
5	99.92	45.23

Circle Center At X = 64.2 ; Y = 110.9 and Radius, 74.9

*** 1.409 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	36.76
2	79.99	37.26
3	89.83	39.02
4	99.37	42.03
5	108.44	46.24
6	109.78	47.08

Circle Center At X = 71.2 ; Y = 114.8 and Radius, 78.0

*** 1.551 ***

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	71.05	34.08
3	80.95	35.48

4	90.20	39.29
5	97.53	44.79

Circle Center At X = 70.5 ; Y = 73.9 and Radius, 39.9

*** 1.655 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.78	32.84
2	57.75	33.62
3	67.64	35.09
4	77.41	37.23
5	87.00	40.04
6	96.38	43.51
7	100.41	45.33

Circle Center At X = 41.5 ; Y = 177.6 and Radius, 144.9

*** 1.730 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	70.93	33.31
3	80.93	33.31
4	90.76	35.18
5	100.05	38.86
6	108.49	44.23
7	111.96	47.49

Circle Center At X = 76.0 ; Y = 86.1 and Radius, 53.0

*** 1.824 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.11	35.20
2	70.70	32.37
3	80.70	32.49
4	90.23	35.54
5	98.43	41.26

6	101.82	45.59

Circle Center At X = 75.3 ; Y = 65.7 and Radius, 33.7

*** 1.881 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.89	32.00
2	48.89	31.73
3	58.88	32.15
4	68.82	33.24
5	78.66	35.00
6	88.36	37.42
7	97.88	40.50
8	107.16	44.22
9	115.25	48.11

Circle Center At X = 47.8 ; Y = 179.1 and Radius, 147.3

*** 1.923 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.22	33.63
2	62.04	31.73
3	72.04	31.51
4	81.93	32.97
5	91.44	36.07
6	100.30	40.71
7	108.25	46.78
8	108.27	46.80

Circle Center At X = 68.3 ; Y = 90.9 and Radius, 59.5

*** 1.929 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.89	32.00
2	48.87	31.38
3	58.87	31.50

4	68.83	32.34
5	78.71	33.91
6	88.44	36.20
7	97.99	39.19
8	107.28	42.88
9	116.29	47.23
10	119.04	48.82

Circle Center At X = 52.3 ; Y = 168.0 and Radius, 136.7

*** 1.940 ***

Failure Surface Specified By 10 Coordinate Points

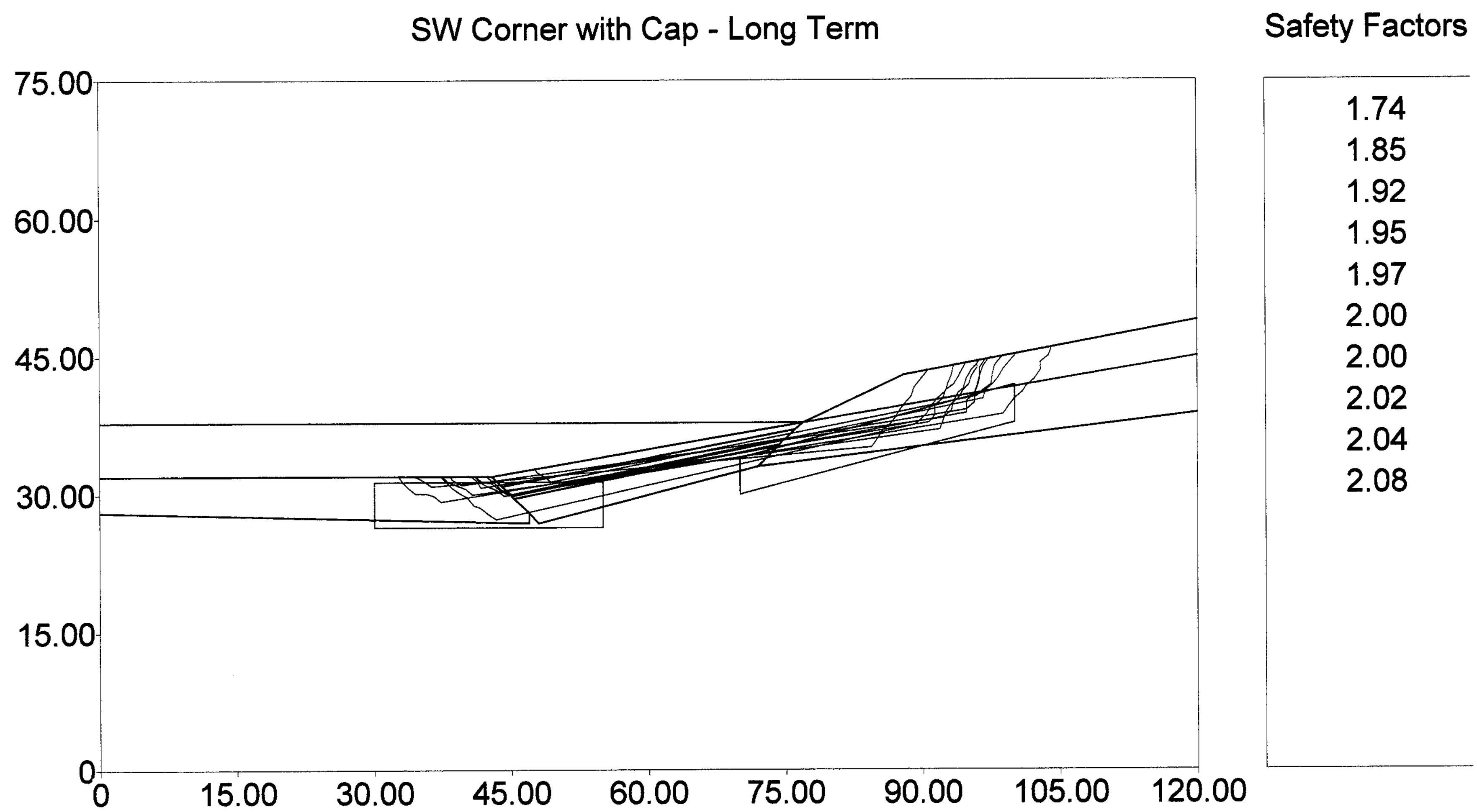
Point No.	X-Surf (ft)	Y-Surf (ft)
1	34.44	32.00
2	44.44	31.75
3	54.44	32.07
4	64.40	32.96
5	74.29	34.41
6	84.09	36.42
7	93.75	38.98
8	103.26	42.09
9	112.57	45.73
10	119.53	48.91

Circle Center At X = 43.8 ; Y = 208.0 and Radius, 176.3

*** 1.957 ***

```
               Y           A       X       I       S          F       T

               0.00     15.00     30.00     45.00     60.00     75.00

X       0.00 +---------+--------*+*---W----+---------+---------+
             -
             -
             -
             -
             -
       15.00 +
             -
             -
             -
             -
             -
A      30.00 +                     .
             -
             -                     0
             -                  ..
             -                   ...7
```

```
                -        ... *
X      45.00 +            .  **
                -     ....**  4
                -     .  ....7
                -      ......  8
                -     .  .. .0
                -    ........  4.
I      60.00 +    ... ... 7.3
                -    ........8
                -    . ... ...0 1
                -     ........  4
                -    ...... ..53 2
                -    ..... ..8*
S      75.00 +     .. ......0**
                -     ........7 *
                -      ..... .5 32
                -     ........8
                -    .   .......0.1
                -       ........97 4 *
       90.00 +      ......  56.2...
                -     ..........8.....
                -     .   ........0.1..
                -         ........97643
                -       ... ..... 582.1
                -       .  .   . ...0.6
F     105.00 +        .    ..... ...  .
                -              .......5.2
                -          .. ..   ....2
                -                 ....0 5
                -              . . ....7
                -                   .  9.
T     120.00 +                 *   W .*
```



Block 1 files

```
PROFIL
SW Corner with Cap - Long Term
22 4
0.00 32.00 43.00 32.00 3
43.00 32.00 77.00 38.00 2
77.00 38.00 88.00 43.00 1
88.00 43.00 120.00 49.00 1
43.00 32.00 44.00 31.00 3
44.00 31.00 76.00 37.00 4
76.00 37.00 77.00 38.00 1
44.00 31.00 45.00 30.00 3
45.00 30.00 75.00 36.00 5
75.00 36.00 76.00 37.00 1
45.00 30.00 45.20 29.80 3
45.20 29.80 74.80 35.80 6
74.80 35.80 75.00 36.00 1
45.20 29.80 45.40 29.60 3
45.40 29.60 74.60 35.60 7
74.60 35.60 74.80 35.80 1
45.40 29.60 47.00 28.00 3
0.00 28.00 47.00 27.00 8
47.00 28.00 48.00 27.00 8
48.00 27.00 72.00 33.00 8
72.00 33.00 74.60 35.60 1
72.00 33.00 120.00 39.00 8
SOIL
8
105.00 115.00 0.00 22.00 0.00 0.00 2
130.00 135.00 0.00 35.00 0.00 0.00 1
75.00 80.00 50.00 15.00 0.00 0.00 1
105.00 110.00 0.00 30.00 0.00 0.00 1
115.00 125.00 0.00 18.00 0.00 0.00 1
115.00 125.00 0.00 8.00 0.00 0.00 1
110.00 115.00 0.00 30.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 45.00
BLOCK
50 2 1.00
30.00 29.00 55.00 29.00 5.00
70.00 32.00 100.00 40.00 4.00
```

Profile_blcok1_LTcap.out.txt
** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION   SW Corner with Cap - Long Term

BOUNDARY COORDINATES

4 Top Boundaries
22 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	3
2	43.00	32.00	77.00	38.00	2
3	77.00	38.00	88.00	43.00	1
4	88.00	43.00	120.00	49.00	1
5	43.00	32.00	44.00	31.00	3
6	44.00	31.00	76.00	37.00	4
7	76.00	37.00	77.00	38.00	1
8	44.00	31.00	45.00	30.00	3
9	45.00	30.00	75.00	36.00	5
10	75.00	36.00	76.00	37.00	1
11	45.00	30.00	45.20	29.80	3
12	45.20	29.80	74.80	35.80	6
13	74.80	35.80	75.00	36.00	1
14	45.20	29.80	45.40	29.60	3
15	45.40	29.60	74.60	35.60	7
16	74.60	35.60	74.80	35.80	1
17	45.40	29.60	47.00	28.00	3
18	0.00	28.00	47.00	27.00	8
19	47.00	28.00	48.00	27.00	8
20	48.00	27.00	72.00	33.00	8
21	72.00	33.00	74.60	35.60	1
22	72.00	33.00	120.00	39.00	8

ISOTROPIC SOIL PARAMETERS

8 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	22.0	0.00	0.0	2
2	130.0	135.0	0.0	35.0	0.00	0.0	1
3	75.0	80.0	50.0	15.0	0.00	0.0	1
4	105.0	110.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	0.0	18.0	0.00	0.0	1
6	115.0	125.0	0.0	8.0	0.00	0.0	1
7	110.0	115.0	0.0	30.0	0.00	0.0	1
8	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	45.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

50 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 1.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	30.00	29.00	55.00	29.00	5.00
2	70.00	32.00	100.00	40.00	4.00

Following Are Displayed The Ten Most Critical Of The Trial

Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	41.01	32.00
2	41.11	31.94
3	42.02	31.52
4	43.00	31.32
5	43.76	30.66
6	44.63	30.17
7	45.60	29.93
8	96.67	40.28
9	96.90	41.25
10	97.61	41.96
11	98.30	42.68
12	98.87	43.50
13	99.51	44.26
14	100.09	45.08
15	100.15	45.28

*** 1.743 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	41.04	32.00
2	41.72	31.48
3	42.65	31.12
4	43.50	30.59
5	44.21	29.89
6	94.76	39.05
7	95.01	40.02
8	95.70	40.75
9	95.96	41.71
10	96.38	42.62
11	96.49	43.61
12	96.93	44.52
13	96.94	44.68

*** 1.847 ***

Failure Surface Specified By 16 Coordinate Points

Point X-Surf Y-Surf

No.	(ft)	(ft)
1	42.28	32.00
2	42.40	31.95
3	43.14	31.28
4	43.89	30.63
5	44.80	30.20
6	98.89	38.92
7	99.57	39.66
8	100.26	40.38
9	100.96	41.10
10	101.56	41.90
11	102.26	42.61
12	102.97	43.31
13	103.05	44.31
14	103.75	45.02
15	104.09	45.96
16	104.15	46.03

*** 1.919 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.49	32.79
2	47.82	32.46
3	48.64	31.88
4	49.53	31.43
5	96.13	40.59
6	96.81	41.32
7	97.52	42.03
8	97.59	43.03
9	98.08	43.90
10	98.70	44.68
11	99.06	45.07

*** 1.952 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.54	32.00
2	38.76	31.78
3	39.61	31.25
4	92.46	38.35
5	93.11	39.11
6	93.59	39.99
7	94.00	40.90
8	94.70	41.61
9	94.87	42.59
10	95.51	43.36

11	96.18	44.10
12	96.41	44.58

*** 1.967 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	34.48	32.00
2	34.60	31.89
3	35.58	31.68
4	36.29	30.98
5	84.53	35.32
6	85.22	36.04
7	85.67	36.94
8	86.36	37.65
9	86.98	38.44
10	87.56	39.26
11	88.27	39.96
12	88.97	40.68
13	89.20	41.65
14	89.88	42.39
15	90.49	43.18
16	90.61	43.49

*** 2.004 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	37.36	32.00
2	37.95	31.63
3	38.65	30.92
4	39.43	30.30
5	40.21	29.66
6	40.93	28.98
7	41.86	28.61
8	42.58	27.91
9	43.39	27.32
10	89.14	37.43
11	89.83	38.16
12	90.53	38.87
13	91.21	39.61
14	91.80	40.41
15	92.51	41.12
16	92.79	42.08
17	93.35	42.91
18	93.59	43.88
19	93.73	44.07

*** 2.004 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	37.46	32.00
2	38.20	31.55
3	39.13	31.19
4	40.02	30.73
5	40.78	30.08
6	91.90	37.11
7	92.27	38.04
8	92.62	38.97
9	93.33	39.68
10	94.04	40.39
11	94.53	41.26
12	95.21	41.99
13	95.39	42.97
14	96.09	43.68
15	96.19	44.53

*** 2.019 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	32.67	32.00
2	33.16	31.57
3	33.89	30.89
4	34.69	30.28
5	35.69	30.27
6	36.58	29.83
7	37.35	29.18
8	90.77	37.90
9	91.39	38.68
10	91.57	39.67
11	92.22	40.42
12	92.68	41.31
13	93.39	42.02
14	94.00	42.80
15	94.59	43.61
16	94.93	44.30

*** 2.043 ***

Failure Surface Specified By 11 Coordinate Points

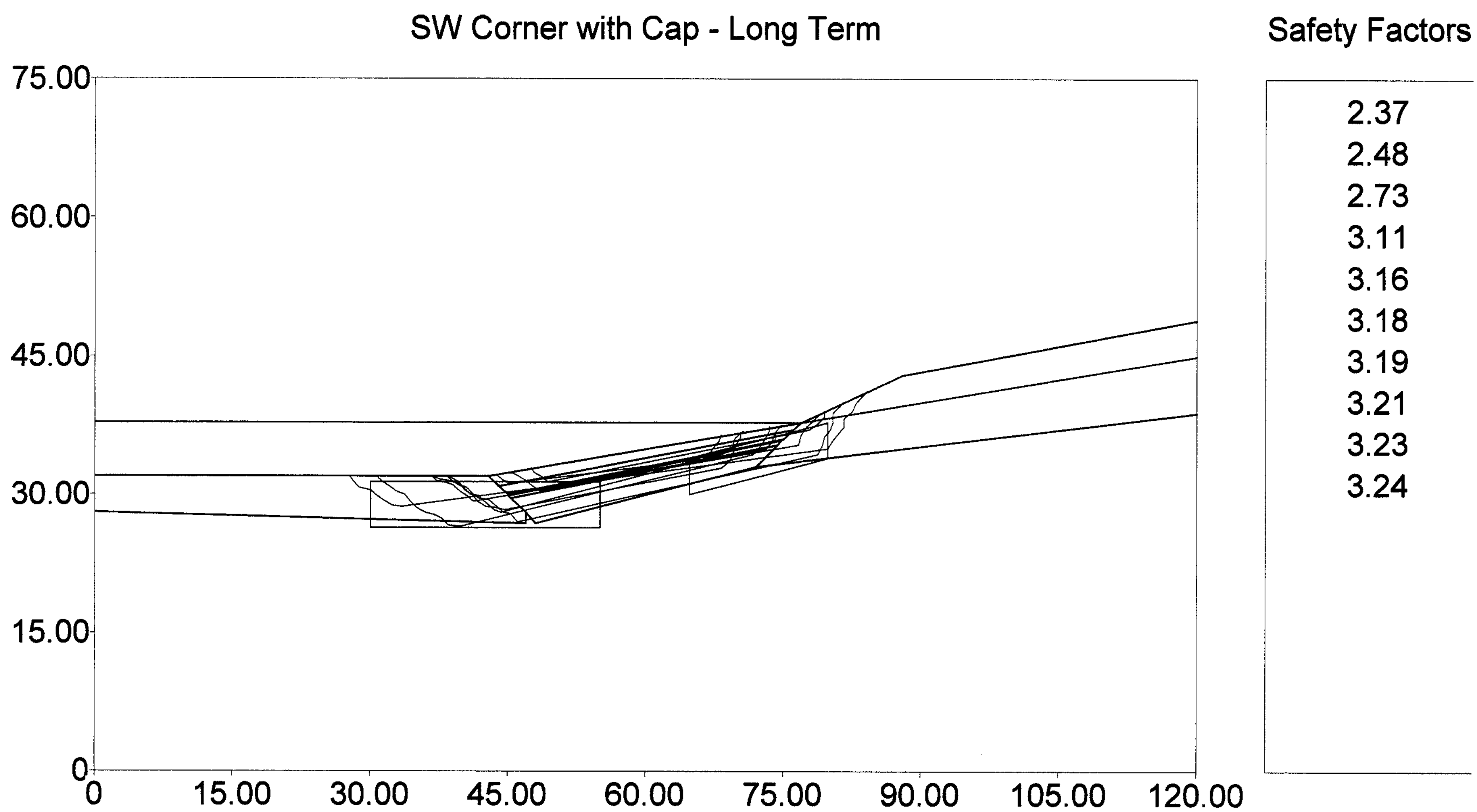
Point X-Surf Y-Surf

No.	(ft)	(ft)
1	40.67	32.00
2	41.18	31.58
3	41.89	30.88
4	94.95	39.26
5	95.66	39.97
6	95.90	40.94
7	96.16	41.91
8	96.30	42.90
9	96.75	43.79
10	97.40	44.55
11	97.50	44.78

*** 2.083 ***

```
             Y           A     X     I     S             F     T

             0.00     15.00     30.00     45.00     60.00     75.00

X       0.00 +---------+--------*+*---W----+---------+---------+
             -
             -
             -
             -
             -
       15.00 +
             -
             -
             -                    .
             -                   ..
             -                  ...
A      30.00 +                 ....
             -                 ...9
             -                 ..96
             -                 .995
             -                  771
             -                 772*
X      45.00 +                 ..**.
             -                 **.44
             -                 ...4
             -                 ...
             -                 ..
             -
I      60.00 +
             -
             -
             -
             -                    ..
             -                     *...
S      75.00 +                    ...**
             -                      ..*.
             -                     .....
             -                      .....
             -                       66...
             -                       .666.*
       90.00 +                       .77666
```

```
               -                      85577
               -                       22258
               -                       .1122
               -                       33.11
               -                         333.
F     105.00   +                           .3
               -
               -
               -
               -
               -
T     120.00   +                       *   W  *
```



Block 2 Files

```
PROFIL
SW Corner with Cap - Long Term
22 4
0.00 32.00 43.00 32.00 3
43.00 32.00 77.00 38.00 2
77.00 38.00 88.00 43.00 1
88.00 43.00 120.00 49.00 1
43.00 32.00 44.00 31.00 3
44.00 31.00 76.00 37.00 4
76.00 37.00 77.00 38.00 1
44.00 31.00 45.00 30.00 3
45.00 30.00 75.00 36.00 5
75.00 36.00 76.00 37.00 1
45.00 30.00 45.20 29.80 3
45.20 29.80 74.80 35.80 6
74.80 35.80 75.00 36.00 1
45.20 29.80 45.40 29.60 3
45.40 29.60 74.60 35.60 7
74.60 35.60 74.80 35.80 1
45.40 29.60 47.00 28.00 3
0.00 28.00 47.00 27.00 8
47.00 28.00 48.00 27.00 8
48.00 27.00 72.00 33.00 8
72.00 33.00 74.60 35.60 1
72.00 33.00 120.00 39.00 8
SOIL
8
105.00 115.00 0.00 22.00 0.00 0.00 2
130.00 135.00 0.00 35.00 0.00 0.00 1
75.00 80.00 50.00 15.00 0.00 0.00 1
105.00 110.00 0.00 30.00 0.00 0.00 1
115.00 125.00 0.00 18.00 0.00 0.00 1
115.00 125.00 0.00 8.00 0.00 0.00 1
110.00 115.00 0.00 30.00 0.00 0.00 1
140.00 145.00 0.00 35.00 0.00 0.00 1
WATER
1 62.40
3
0.00 38.00
77.00 38.00
120.00 45.00
BLOCK
50 2 1.00
30.00 29.00 55.00 29.00 5.00
65.00 32.00 80.00 36.00 4.00
```

** PCSTABL6 **

by
Purdue University

modified by
Peter J. Bosscher
University of Wisconsin-Madison

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

PROBLEM DESCRIPTION SW Corner with Cap - Long Term

BOUNDARY COORDINATES

4 Top Boundaries
22 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	32.00	43.00	32.00	3
2	43.00	32.00	77.00	38.00	2
3	77.00	38.00	88.00	43.00	1
4	88.00	43.00	120.00	49.00	1
5	43.00	32.00	44.00	31.00	3
6	44.00	31.00	76.00	37.00	4
7	76.00	37.00	77.00	38.00	1
8	44.00	31.00	45.00	30.00	3
9	45.00	30.00	75.00	36.00	5
10	75.00	36.00	76.00	37.00	1
11	45.00	30.00	45.20	29.80	3
12	45.20	29.80	74.80	35.80	6
13	74.80	35.80	75.00	36.00	1
14	45.20	29.80	45.40	29.60	3
15	45.40	29.60	74.60	35.60	7
16	74.60	35.60	74.80	35.80	1
17	45.40	29.60	47.00	28.00	3
18	0.00	28.00	47.00	27.00	8
19	47.00	28.00	48.00	27.00	8
20	48.00	27.00	72.00	33.00	8
21	72.00	33.00	74.60	35.60	1
22	72.00	33.00	120.00	39.00	8

ISOTROPIC SOIL PARAMETERS

8 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	115.0	0.0	22.0	0.00	0.0	2
2	130.0	135.0	0.0	35.0	0.00	0.0	1
3	75.0	80.0	50.0	15.0	0.00	0.0	1
4	105.0	110.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	0.0	18.0	0.00	0.0	1
6	115.0	125.0	0.0	8.0	0.00	0.0	1
7	110.0	115.0	0.0	30.0	0.00	0.0	1
8	140.0	145.0	0.0	35.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	38.00
2	77.00	38.00
3	120.00	45.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

50 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 1.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	30.00	29.00	55.00	29.00	5.00
2	65.00	32.00	80.00	36.00	4.00

Following Are Displayed The Ten Most Critical Of The Trial

Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	45.49	32.44
2	46.07	32.06
3	47.00	31.69
4	47.75	31.03
5	48.59	30.48
6	74.13	35.74
7	74.18	36.74
8	74.86	37.48
9	74.94	37.64

*** 2.365 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.01	32.00
2	43.23	31.87
3	43.94	31.17
4	44.65	30.46
5	45.58	30.11
6	73.33	35.10
7	74.02	35.83
8	74.19	36.81
9	74.90	37.52
10	74.91	37.63

*** 2.476 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.60	32.00
2	38.66	31.95
3	39.55	31.49
4	40.28	30.81
5	40.99	30.10
6	41.97	29.90
7	42.67	29.19

8	43.45	28.56
9	44.27	28.00
10	68.77	34.59
11	69.39	35.37
12	69.97	36.19
13	70.66	36.88

*** 2.733 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	36.71	32.00
2	37.15	31.59
3	38.15	31.51
4	39.09	31.18
5	39.80	30.48
6	40.56	29.83
7	41.33	29.19
8	76.69	35.49
9	77.06	36.42
10	77.51	37.32
11	78.16	38.08
12	78.86	38.79
13	78.93	38.88

*** 3.109 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.49	32.79
2	47.82	32.46
3	48.64	31.88
4	49.53	31.43
5	78.06	37.11
6	78.75	37.84
7	79.46	38.55
8	79.50	39.14

*** 3.161 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	43.78	32.14
2	44.54	31.64
3	45.48	31.31
4	67.05	33.99
5	67.38	34.94
6	67.97	35.74
7	68.20	36.45

*** 3.182 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.61	32.00
2	38.78	31.84
3	39.55	31.20
4	40.50	30.92
5	41.22	30.21
6	41.98	29.57
7	42.98	29.47
8	43.77	28.86
9	44.57	28.26
10	45.50	27.90
11	46.21	27.19
12	78.71	34.49
13	79.19	35.37
14	79.68	36.23
15	80.32	37.01
16	80.49	37.99
17	80.59	38.99
18	81.28	39.71
19	81.54	40.06

*** 3.187 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.78	32.00
2	28.29	31.57
3	29.00	30.87
4	29.97	30.63
5	30.69	29.94
6	31.49	29.34
7	32.43	28.98
8	33.41	28.79
9	79.86	35.13
10	80.55	35.85
11	81.18	36.63
12	81.79	37.42
13	81.81	38.42

14	82.51	39.13
15	83.09	39.95
16	83.73	40.72
17	84.35	41.34

*** 3.207 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	36.75	32.00
2	36.75	32.00
3	37.74	31.86
4	38.70	31.60
5	39.67	31.36
6	40.39	30.65
7	41.15	30.01
8	41.86	29.31
9	42.76	28.87
10	43.73	28.63
11	44.72	28.45
12	68.47	32.83
13	69.12	33.58
14	69.52	34.50
15	69.83	35.45
16	70.32	36.33
17	70.34	36.82

*** 3.228 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.96	32.00
2	31.29	31.68
3	32.11	31.10
4	32.88	30.47
5	33.72	29.93
6	34.51	29.31
7	35.29	28.68
8	36.05	28.03
9	37.02	27.80
10	37.96	27.44
11	38.71	26.78
12	39.71	26.66
13	71.74	34.45
14	72.44	35.16
15	73.11	35.91
16	73.43	36.86
17	73.69	37.42

```
       ***     3.236   ***


          Y           A     X     I     S            F     T

           0.00     15.00     30.00     45.00     60.00     75.00
X     0.00 +---------+---------*+*---W----+---------+---------+
           -
           -
           -
           -
           -
     15.00 +
           -
           -                    .
           -                   ..
           -                  ...
           -                  ..8
A    30.00 +                 ..88
           -                 .880
           -                 .00.
           -                 00.3
           -                 0.33
           -                 .33*
X    45.00 +                 73**1
           -                 **115
           -                 ...5.
           -                 ....
           -                 . .
           -
I    60.00 +
           -
           -                   ....
           -                     966
           -                    .9333
           -                    .*200
S    75.00 +                     ..**
           -                      74*.
           -                      8774.
           -                        877
           -                           8
           -                            *
     90.00 +
           -
           -
           -
           -
           -
F   105.00 +
           -
           -
           -
           -
           -
T   120.00 +                         *   W  *
```